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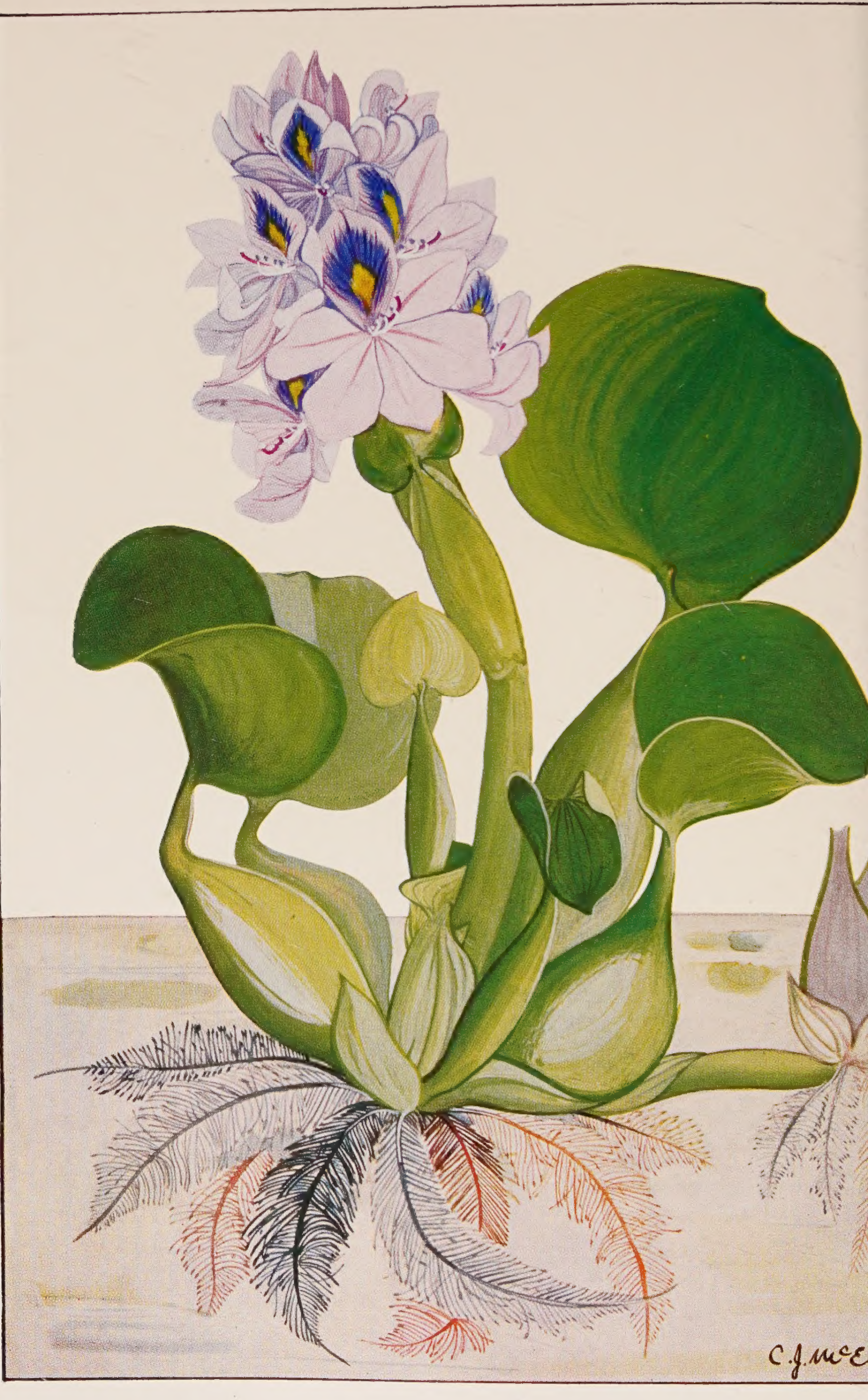

Eichhornia Crassipes

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HARMFUL AQUATIC PLANTS IN AFRICA AND MADAGASCAR

Joint CCTA/CSA Project
No. 14

by

HIRAM WILD

(Illustrations by Cecilia McEwen)

SALISBURY
1961

PREFACE

One of the major problems in the fight against harmful aquatic plants in Africa, as in other parts of the world, is that infestations of particular species have often spread alarmingly before their danger is realized. This may be because the botanical identity of the plant is not known early enough, or, alternatively because it is not recognized that the plant constitutes a potential danger as a harmful plant.

At the eighth meeting of the Council of CSA in Salisbury (1957), therefore, an item was included in the agenda drawn up for the CSA Symposium on *Eichhornia crassipes* (Leopoldville, 1957) so that the possibility could be examined of preparing a pamphlet on aquatic plants which were already known to be harmful in Africa and Madagascar, or were potentially harmful. With the distribution of this pamphlet it would, it was hoped, be much easier to give early warning of new infestations by harmful aquatic plants and thereby save time and money in their eradication. The Leopoldville Symposium recommended forthwith that such a pamphlet be published and final approval for the project was given at the Fifteenth Session of CCTA in Tananarive, February, 1960.

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INTRODUCTION

IN THE PREPARATION of this work it has been recognized that the majority of persons likely to make use of it will have no specialized botanical knowledge. This being so, emphasis has been laid on the production of clear illustrations and the botanical descriptions are kept as short and simple as possible. Nevertheless, no attempt has been made to substitute, in the English text, common English words for descriptive botanical terms. To do so would render the preparation of accurate descriptions impossible and would, furthermore, make the preparation of an accurate French translation almost impossible. Any difficulties which this may cause should be removed by the inclusion of the glossary of botanical terms employed.

The choice of species was made by drawing up a preliminary list with the aid of my colleagues in the Herbaria of Kew and the British Museum (Natural History) in 1959. This was then circulated to all the Agricultural or other appropriate Departments of the African territories south of the Sahara, Zanzibar, Madagascar, Mauritius and the Seychelles. With the aid of their suggestions, the list was expanded and a rearrangement of their order in the list was made in the light of their opinions on the relative importance of the plants in their territories. It was not intended in the first place to deal with subaquatic weeds that are primarily pests associated with rice cultivation or irrigated crops but the questionnaire indicated that there was a strong feeling that they should not be neglected and they have consequently been included.

It was not very difficult to decide on the plants of major importance although not all are of the same importance. Most, like *Eichhornia, Pistia* and *Typha*, have a very wide distribution in the area we are dealing with. Others, such as *Salvinia auriculata* and *Microcystis toxica*, are only of importance at present in relatively small areas, however, where these latter do occur they are of major importance. In the case of the plants of potential importance a certain amount of guesswork has had to be resorted to. Only time will tell whether they will become of major importance in the future. Finally, the choice of plants known to be troublesome in other parts of the world and which might be dangerous if introduced to Africa and Madagascar proved particularly troublesome. So much depends on chance and a plant that is at present quite harmless in its native environment could prove of catastrophic importance if introduced to our area. The behaviour of *Salvinia auriculata* is an illustration of the dangers of such introductions. The moral to be drawn is clear: the greatest caution should be exercised in introducing any exotic aquatic plants to Africa and in particular the practice, so common nowadays, of constantly introducing new exotic species to aquarium cultivation should be discouraged. Aquarium enthusiasts should instead be encouraged to cultivate Africa's own indigenous aquatics.

Where possible the information on the chemical control of the species dealt with has been drawn from African or Madagascan experience but often no such information was available. It was thought useful in such cases to include information on methods tried elsewhere on our species or closely related species, as this should give a lead to future investigations. There is a final category of species in which no information on control measures is available at all. This should prove a stimulus to future work on the subject. To save the repetition of cumbersome formulae the common names of herbicides are used when they exist. A list of such common names with their chemical abbreviations follows the glossary of botanical terms.

The order in which the species appear in the text is clear from the arrangement of the list of plants given at the beginning of the main text (pp. 6-8). However, a little further explanation may be helpful The plants of major importance are naturally dealt with first and within the subdivisions of free-floating plants, plants rooting in mud and plants troublesome in irrigated crops, they appear roughly in order of their importance as harmful plants. In Section III the plants dangerous in other parts of the world are also listed in order of their potential importance although, in this case, not much attention should be paid to these relative assessments. In Section II, consisting of the plants presenting a potential danger which are already known from Africa, they are divided into the same subsections as the plants of major importance but within these subsections it did not prove possible, in the present state of our knowledge, to make a sufficiently firm prognosis as to their relative importance in the future to enable them to be listed on this basis. Consequently, rather than leave their relative positions to mere chance, they follow the sequence of families according to the Bentham and Hooker system except that the monocotyledons, which are usually the most important in our sense, are listed first and the few cryptogams are put before the phanerogams.

In deciding on the order of the illustrations several alternatives presented themselves. It seemed desirable at first to place together or near each other (so that they could be distinguished more easily) plants that could be confused by the layman, but as for reasons of economy a large proportion of the plates depict several plants and also because it was decided in any case to segregate the plants of major importance (other than in irrigated crops) and represent them all by full-page illustrations, it was not possible to do this satisfactorily. An attempt to have put them in some taxonomic order would have struck the same difficulties and in any case would have had no particular advantage in this context. Plants of similar importance or similar appearance are often quite unrelated botanically. This is especially the case in aquatic plants where habitat plays such a large part in modifying their morphology. *Ceratophyllum* and *Myriophyllum* species or *Nymphaea* and *Nymphoides* species immediately spring to mind as examples of this kind of thing which are represented in this handbook. Because of these difficulties the easy way out was taken and the illustrations follow the order in which they appear in the text.

It will be readily realized that the preparation of this work has involved the assistance and collaboration of many others besides myself. The number in fact is so large that it is not possible to list them in detail. I would, however, like to thank first my taxonomic colleagues in the Herbaria of the British Museum (Natural History), Kew and Salisbury; in the case of the two former institutions for help in producing the preliminary list and in the case of the latter for help with taxonomic problems encountered whilst writing the work. Secondly, the production of a sensible and comprehensive list would not have been possible without the very ready assistance of the heads of Agricultural Departments and Research Institutes of the African territories south of the Sahara, Madagascar, Mauritius, the Seychelles and Zanzibar. To them must be added their many colleagues whom they consulted on my behalf and who so readily provided me with much valuable information.

After the production of the rough draft of the work, copies of it were sent to a number of authorities with special knowledge of the major regions of Africa and Madagascar. They have been able to suggest a number of alterations to the comments on the distribution and importance of various plants which occur in their own regions. These authorities, to whom I am particularly grateful, are as follows: Dr. R. A. Dyer and Mr. R. G. Strey of the National Herbarium, Pretoria; Professor A. Fernandes of the Instituto Botânico, Coimbra, Portugal; Professor J. Lebrun and Dr. R. Germain of the Institut National pour l'Etude Agronomique du Congo; Professor J. Millot, until recently Director of the Institut de Récherche Scientifique de Madagascar, and M. M. Descoings, formerly of the same institution; Professor Th. Monod, Director of the Institut Français d'Afrique Noire, Dakar; Professor J. L. Trochain, Director of the Institut Botanique, Montpellier, and the Institut d'Etudes Centrafricaines, Brazzaville; and Dr. Bernard Verdcourt, of the East African Herbarium, Nairobi.

I would also like to thank very warmly Mr. J. E. Dandy, Keeper of the Department of Botany, British Museum (Natural History) who has checked the botanical nomenclature. Dr. G. R. Bates, Chief Botanist and Plant Pathologist, Federal Department of Agriculture, Salisbury, Professor J. Lebrun and Dr. E. T. Verdier, Scientific Secretary of CSA, have given me valuable guidance in general editorial matters.

Finally, I must acknowledge once again that the value of such a work as this will rest largely on the quality of its illustrations. For the accuracy and attractiveness of these I must thank our artist, Mrs. C. McEwen.

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LIST OF HARMFUL AQUATIC PLANTS

I. PLANTS OF MAJOR IMPORTANCE (ALREADY KNOWN IN AFRICA OR MADAGASCAR)

1° PLANTS TROUBLESOME IN DAMS, RIVERS, IRRIGATION FURROWS, ETC.

(a) Free Floating Plants

1. *Eichhornia crassipes*
2. *Salvinia auriculata*
3. *Pistia stratiotes*
4. *Microcystis toxica*

(b) Plants Rooting in the Mud (Fixed Plants)

5. *Cyperus papyrus*
6. *Typha* spp.
7. *Vossia cuspidata*
8. *Nymphaea caerulea*
9. *Potamogeton richardii*

2° PLANTS TROUBLESOME IN IRRIGATED CROPS (i.e., RICE, ETC.), OFTEN SUBAQUATIC

10. *Oryza perennis*
11. *Ischaemum rugosum*
12. *Cyperus esculentus*
13. *Cyperus rotundus*
14. *Echinochloa stagnina*

II. PLANTS PRESENTING A POTENTIAL DANGER

1° PLANTS TROUBLESOME IN DAMS, RIVERS, IRRIGATION FURROWS, ETC.

(a) Free Floating Plants

15. *Azolla africana*
16. *Lemna* spp.
17. *Wolffia arrhiza*
18. *Trapa natans*
19. *Ceratophyllum demersum*

(b) Plants Rooting in the Mud (Fixed Plants)

20. *Chara* spp.
21. *Marsilea* spp.
22. *Microlepia speluncae*
23. *Ottelia ulvifolia*
24. *Vallisneria aethiopica*
25. *Typhonodorum lindleyanum*
26. *Alisma plantago-aquatica*
27. *Aponogeton desertorum*
28. *Najas* spp.
29. *Lagarosiphon* spp.
30. *Scirpus cubensis*
31. *Scirpus fluitans*
32. *Phragmites mauritianus*
33. *Myriophyllum spicatum*
34. *Ludwigia adscendens*
35. *Nymphoides indica*

2° PLANTS TROUBLESOME IN IRRIGATED CROPS (i.e., RICE, ETC.), OFTEN SUBAQUATIC

36. *Sagittaria guayanensis*
37. *Cyperus difformis*
38. *Cyperus digitatus*
39. *Pycreus mundtii*

40. *Pycreus tremulus*
41. *Scirpus juncoides*
42. *Eleocharis dulcis*
43. *Leersia hexandra*
44. *Mimosa pigra*
45. *Neptunia oleracea*
46. *Bacopa erecta*
47. *Sphenoclea zeylanica*

III. PLANTS DANGEROUS IN OTHER PARTS OF THE WORLD (NOT KNOWN IN AFRICA OR MADAGASCAR SO FAR)

48. *Elodea canadensis*
49. *Alternanthera philoxeroides*
50. *Hydrocleys nymphoides*
51. *Sparganium* spp.
52. *Nelumbo nucifera*

I. PLANTS OF MAJOR IMPORTANCE

1°. PLANTS TROUBLESOME IN DAMS, RIVERS, IRRIGATION FURROWS, ETC.

(a) FREE FLOATING PLANTS

1. Eichhornia crassipes (Mart.) Solms **Pontederiaceae**
Water Hyacinth *Frontispiece*

DESCRIPTION: A free floating (rarely rooting in mud), stoloniferous plant with fine feathery roots. Leaves in a rosette with swollen spongy petioles up to c.20 cm. long; leaf-lamina bright green, somewhat polished, orbicular or oblate, up to c.15 cm. broad, glabrous. Inflorescence a spike of usually about eight flowers borne on a thick scape slightly longer than the leaves with a leafy bract near its middle. Flowers up to c.5 cm. in diameter, of six lobes united below into a narrow tube; lobes in two series, pale lilac or pale mauve, the upper lobe with a yellow marking surrounded by a deep blue margin. Stamens six, attached to the tube; styles sometimes of three different lengths in the same plant. Fruit a membranous three-locular capsule with many ribbed seeds.

DISTRIBUTION AND IMPORTANCE: First described as *Pontederia crassipes* by Martius from Brazil, it is widespread in tropical America and also occurs in Florida, California and Texas. It has now become one of the most serious aquatic weeds in many parts of the tropics and is of increasing importance in Africa. It was apparently introduced to Egypt in the period 1879 - 92 (Täckholm and Drar, 1950) and has probably been known in Natal since early in this century. It is known to be particularly troublesome today in Angola (Congo River only), Congo (Leopoldville) in the Congo basin and Congo (Brazzaville) in the Congo, Ubangi and Sangha rivers, troublesome but not so serious in Madagascar, Moçambique (Incomati River), Tanganyika (Pangani River), Natal and the Eastern Cape in South Africa, and Southern Rhodesia. It has been recorded in cultivation in South West Africa (Okovango). Its greatest potential danger in Africa is probably to the Senegal, Niger and Logone basins in West Africa, the upper basin of the Nile in the Sudan and East Africa, to Lake Albert and its tributaries, Lake Victoria and the Kagera basin in the Congo (Leopoldville), the Okovango River system in South West Africa and Bechuanaland, and to the Sabi system in Southern Rhodesia. It principally causes trouble by interfering with navigation in large rivers, blocks irrigation canals and fills dams. The magnitude of the problem is shown by the fact that in spite of an expenditure of 50 million Belgian francs in 1956 - 7, 150 tons per hour of *Eichhornia* were still passing through Leopoldville on the waters of the Congo River (Lebrun, 1959[1]). The plant obviously spreads extremely rapidly, usually by vegetative means; any broken-off portion of the plant soon reproduces vegetatively. To a larger extent than it is usually given credit for it can also spread by means of seed. After fertilization the inflorescence bends over and the seeds finally sink to the muddy bottom. If the water then dries up the seeds lie dormant until covered by water once more when seedlings appear submerged on the bottom. After some weeks they break away from the rootstock and float to the surface. The plant's buoyancy is due to the air contained in the swollen petioles. The position of the leaf-laminas enables them to act as sails and so wind can spread the plant upstream if the current is not too strong. In West Africa at least growth of the plant is limited by a pH of less than 4.2. The plant can be fed to cattle or pigs, or used as a manure, although it will probably not be profitable commercially to exploit it in this way.

An indigenous African species, *E. diversifolia* (Vahl) Urb., has been reported as presenting a potential danger in the Gambia. It differs from *E. crassipes* in having cordate floating leaves up to 2.5 cm. long on petioles which are not swollen. It also has linear submerged leaves growing from elongated stems and the flowers are blue and only about 1.2 cm. in diameter. It is recorded as indigenous from Southern Rhodesia northwards to the Gambia. It also occurs in the Sudan, East Africa and Madagascar.

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[1] LEBRUN, J., La lutte contre le développement de l'Eichhornia crassipes. *Bull. Agric. Congo Belge,* 1959, **50** (1), 251 - 2 and *Bull. Acad. R. Sc. Coloniales, Bruxelles,* Nlle. Sér., **4**: 1407 - 1412 (1959).

CONTROL: Extremely difficult to eradicate entirely because small plants always seem to survive hidden by other vegetation or alternatively because seed survives when mature plants are all killed. On the other hand it is relatively easy to kill with applications of 3 - 7 lb./acre 2, 4-D (preferably the amine or ester derivatives) hormone weed killer. Reinfestations almost invariably occur due to the escape of a few plants and spraying has to continue as infestations build up again. A useful general bibliography relating to the species can be found in Täckholm and Drar, *Flora of Egypt*, Vol. II, pp. 441 - 8, and a symposium of the current position in Africa is given in CSA/CCTA Publication No. 27, *Eichhornia crassipes* Conference, Leopoldville, 1957.

2. **Salvinia auriculata** Aubl. — **Salviniaceae**

Salvinia — Tab. I

DESCRIPTION: A free floating (rarely rooting in mud) fern. The plant consists of pairs of unwettable floating leaves and a finely dissected root-like submerged leaf at each node of a horizontal stem. Floating leaves broadly elliptic, not as a rule exceeding 3 cm. long, deeply emarginate at the apex, cordate at the base, upper surface covered with close parallel rows of long hairs (the hairs are very distinctive consisting of a single basal portion branching above into three to four arms which re-unite at their apices in a kind of cage-like arrangement), lower leaf-surface glabrous except for simple hairs perhaps acting as rootlets near the midrib. Submerged leaf up to c.5 cm. long, root-like, fine and feathery. Spores tend to be formed when plants become overcrowded and are contained in ellipsoid or globose sporocarps borne on the submerged leaves. Sporocarps (? immature) ellipsoid, c.2 - 3 mm. in diameter, on a short stalk c.1 mm. long, densely hairy. Spores very numerous. *Salvinia* species have spores of two kinds, very minute microspores and larger macrospores produced in different sporocarps.

DISTRIBUTION AND IMPORTANCE: Described by Aublet from Guiana but is indigenous over a wide area in

Central and South America from Cuba to southern Brazil. For some time it has been well known as an aquarium plant and has also appeared in various parts of the world as a harmful weed. In Ceylon it is estimated to have spread over 22,000 acres of rice fields and over 2,000 acres of waterways in 12 years. It has recently become an extremely serious weed on Lake Kariba on the Zambezi River where it is covering large areas with a blanket up to 25 cm. thick and providing a substratum for other sudd-forming species such as *Vossia* and *Scirpus cubensis*. Above Kariba it is known as far upstream as Kazungula on the Zambezi and some 35 miles at least up the Chobe River where it forms the boundary between Bechuanaland and the Caprivi Strip. It is also known on a smaller scale infesting small dams in Natal, the Knysna and Jonkershoek regions of the Cape Province in South Africa, Kenya and the Umtali-Inyazura area of Southern Rhodesia. Its introduction to any other part of Africa would presumably constitute a serious menace. Like water hyacinth, it reproduces vegetatively at an alarming rate when conditions are favourable. Its buoyancy is due to the characteristic hairs on the upper leaf surface which trap air when the plant is submerged. Under cultivation it apparently grows best at temperatures of between 18 and 25° C. (64 and 77° F.). To what extent it spreads by means of its spores is not known but it certainly produces them copiously when growing in crowded conditions.

S. hastata Desv. which is fairly widely distributed in Madagascar and East Tropical Africa from Nyasaland, and probably Moçambique northwards, is reported as a ricefield weed in West Madagascar. It is superficially very like *S. auriculata* but is indigenous and readily distinguished by the fact that the hairs on the upperside of the floating leaves are simple, not branched.

CONTROL: The only herbicide known so far to be generally successful against *S. auriculata* is sodium pentachlorophenol (PCP). The following formulations have been reported successful—

8–10 galls. NaPCP emulsion in 150 galls./acre.

4 galls. NaPCP emulsion/diesoline mixture (1 : 2 by weight) in 25 galls. water/acre.

25 lb. NaPCP in 60 galls. of water/acre.

Further sprayings at 14 - 21 days' intervals may be necessary.

This herbicide is non-toxic to humans and animals but is toxic to fish at concentrations as low as 4 p.p.m. There is an urgent necessity to discover selective herbicides effective against *Salvinia*. No detailed information is to hand at the time of writing but granular diuron has been reported as showing promise.

3. **Pistia stratiotes** L. **Araceae**

Water lettuce Tab. II

DESCRIPTION: A free floating stoloniferous plant consisting of a rosette of leaves with a tuft of long fibrous roots beneath. Leaves pale green, sessile, broadly obovate with a truncate, rounded or broadly emarginate apex, up to 13 cm. long by 5 cm. wide, occasionally even larger, softly pubescent on both sides, tomentose near the base, with 7 - 15 prominent nerves radiating from the base and especially conspicuous below. Inflorescence a typical but unusually small green aroid (i.e., like an arum lily) spathe, sessile in the axils of the leaves and not more than 10 mm. long, tubular below, villous outside and with a ciliate margin. The spadix bearing the individual flowers is shorter than the spathe. Flowers minute; males 3 - 8, each composed of 2 connate 2-locular anthers; female solitary at the base of the spadix. Fruit with numerous very small seeds.

DISTRIBUTION AND IMPORTANCE: Described from Ceylon by Linnaeus but occurs throughout the tropics of the Old and New Worlds. Also found in some subtropical regions, i.e., in the Nile and in Florida. Has been certainly known in Egypt since the time of Pliny (77 A.D.) who records its use in healing wounds and erysipelas (Täckholm and Drar, 1950). Recorded as troublesome in the Upper Nile and particularly as one of the major floating constituents of sudd in the Niger Delta. It is reported as abundant in the rivers of Dahomey, Guinea, Ivory Coast, Mali, Mauretania, Niger, Senegal and Upper Volta. It is troublesome but not critically so in the Gambia, Kenya (Ambolesi National Park) and the littoral regions of Angola and Moçambique. It is known in many other regions of tropical Africa from Ghana to Pondoland in Natal and Madagascar but is not reported as being harmful. It is showing some potential danger in Lake Kariba on the Zambezi. Like water hyacinth this plant blocks irrigation canals and is also important in sudd formation in the deltas of large rivers. It propagates presumably mostly from seed. Seeds at first float on the water for two days then sink and germinate, seedlings appearing at the surface in about five days. At present the plant is not so dangerous as water hyacinth, probably because it is not a relatively recent introduction to Africa, but it may become so with the construction of more large dams and irrigation projects. The plant's buoyancy is caused by the hairiness of the leaves which causes air to be imprisoned if the plant is submerged.

CONTROL: Removal by hand is apparently still practised in the Nile Delta and Nigeria. Very little experimental herbicidal work appears to have been carried out on this weed but simazin at 0.6 gms. per square metre has been reported to give good control after 21 days in India.

4. **Microcystis toxica** Stephens — **Chroococcaceae**

Waterbloom — Tab. III

DESCRIPTION (after Stephens, E. L., Trans. Roy. Soc. S.Afr., **32**, 1: 107 (1949)): A blue-green alga forming colonies; young colonies are at first solid and composed of numerous cells in a colourless gelatinous investment but later become hollow, concave or spongiform. Fully developed colonies are from 0.3 - 2.5 mm. in length or diameter, but are mostly between 0.7 and 1.2 mm. Individual cells spherical, with 3 - 8 pseudovacuoles 3.4 - 7 μ in diameter. Multiplication of colonies initiated by rapid cell division localized in streaks or spots leading to the formation of strands and balls of more or less closely packed cells, the strands variously shaped and loosely united with each other and the balls to form an irregular network. Simultaneously the colony itself expands. Finally the colony becomes brokenly reticulate falling apart into portions and finally into the component strands and balls which develop into new colonies. At all stages the individual balls and strands remain surrounded by the mucilaginous investment.

DISTRIBUTION AND IMPORTANCE: Common in the Transvaal and Orange Free State but not known elsewhere. It may have a wider distribution to the north and should be looked for. In addition one or more other species, probably distinct but very closely related to *M. toxica,* have been recorded in Southern Rhodesia; so far these latter have not proved toxic to cattle. Furthermore, the more or less cosmopolitan *Microcystis aeruginosa* Kütz. is recorded from areas as widely separated as Cape Province, Natal, Southern Rhodesia, Nyasaland, Tanganyika and Lake Victoria-Nyanza (distribution in part from Frémy, P., Les Myxophycées de l'Afrique équatoriale française. Arch. Bot., **3**, Mém. 2 (1929)). This latter species and probably other blue-green algae cause the tainting of drinking water and have been responsible for a certain amount of trouble of this kind in Southern Africa in the last few years.

POISONING BY MICROCYSTIS TOXICA: This species contains an extremely powerful liver poison. Cattle are particularly affected and the plant is also poisonous to fish. Fresh material is the most toxic and as the alga dies the toxin apparently diffuses into the water and soon loses its toxicity. Rapid death follows large doses and photosensitisation is marked in chronic cases. More details may be found in Steyn, D. G., Poisoning of Animals by Algae (Scum or Waterbloom) in Dams and Pans (Department of Agriculture pamphlet, Government Printer, Pretoria, 1945). The species is often wind-driven into creeks where it decays with an appalling stench and shows a play of colours in greens, reds, blues and purples with red fluorescent liquid in cracks in the decaying mass. The nearly related species in Lake Kariba produces the same effect.

CONTROL: Steyn (*loc. sit.*) recommends 1 lb. copper sulphate/200,000 gallons, a concentration which is not poisonous to fish, animals or humans. A more recent recommendation with regard to blue-green algae generallv in that they can be killed by 0.5 - 1 lb./acre phygon-XL. 4 - 5 lb./acre are necessary to kill green algae. At these concentrations the material is not toxic to fish or animals.

(b) PLANTS ROOTING IN THE MUD (FIXED PLANTS)

5. Cyperus papyrus L. **Cyperaceae**
Papyrus Tab. IV

DESCRIPTION: Tall glabrous plant up to 4 m. tall; rhizome woody and stout; flowering stalks leafless, smooth, somewhat 3-angled, surrounded at the base by large leathery acuminate sheaths. Inflorescence a compound umbel with very numerous filiform primary rays 10 - 45 cm. long each surrounded at the base with a narrow brown cylindrical sheath up to 3 cm. long; bracts lanceolate, up to 9 cm. long by 1.2 cm. wide. Secondary umbels 3 - 5-rayed subtended by elongated narrow bracteoles. Spikes 1 - 2 cm. long by 6 - 10 mm. broad; spikelets 6 - 10 mm. long by 1 mm. broad, 6 - 15-flowered. Glumes broadly elliptic, scarcely keeled; style branches 3.

DISTRIBUTION AND IMPORTANCE: Described by Linnaeus from the Mediterranean region but now recorded from Madagascar and Africa generally from St. Lucia Bay, Natal, and Northern Bechuanaland northwards. Also occurs in Sicily, Southern Italy, Palestine and Malta. In some cases these Mediterranean occurrences were probably derived from Egypt.

Papyrus becomes a harmful weed when it either encroaches on open water from the banks or forms sudd, i.e., masses of often free floating vegetation which block rivers or other bodies of water. Papyrus forms impenetrable thickets on these floating rafts of vegetation and is well known to have hindered navigation on the Nile since the earliest times. In the Sudan papyrus sudd is estimated to be responsible also for the loss of 50 per cent. of the White Nile's water through evaporation and transpiration. Particularly in Egypt it also encroaches on irrigation schemes. Apart from Egypt papyrus is looked upon as a major problem in the Niger Delta through sudd formation and in Uganda, Lake Bangweulu in Northern Rhodesia and the Okovango swamps in Bechuanaland through constantly closing navigation channels and interfering with fishing. It is a potential danger in other parts of tropical Africa where future irrigation or large dam projects give it an opportunity to spread harmfully. It is apparently beginning to join in sudd formation in the newly completed Lake Kariba.

CONTROL: So far it appears that control of papyrus has largely been by mechanical means. The construction of and the keeping in repair of good banks to canals and navigation channels is very important in preventing encroachment by papyrus. Work in clearing new channels has apparently been a matter of hand cutting so far but mechanical cutters mounted on boats may provide an answer and the effectiveness of herbicides such as dalapon needs investigation.

6. **Typha** spp. — **Typhaceae**

Bulrush — Tab. V

DESCRIPTION (the African species with which we are concerned here are *T. australis* Schumach. and *T. capensis* Rohrb. They are very similar and for the purposes of this work it is not necessary to deal with them separately). Robust perennial herbs growing from a large creeping rhizome. Stems erect, unbranched, up to 3 or even 4 m. tall. Leaves arising near the base of the stem, linear or strap-shaped, leathery or somewhat spongy, grass-like and elongate-linear, sheathing at the base, gradually tapering to the apex, often as long as or even overtopping the inflorescence. Flowers minute, unisexual, wind-pollinated, very numerous, densely crowded in a terminal spike, the male above and the female below, the two sexes contiguous or separated. Perianth of very slender jointed hairs which give a velvety feel to the inflorescence. The inflorescence bursts open explosively when mature and spreads the minute dry fruits buried in masses of silky hairy perianth segments.

DISTRIBUTION AND IMPORTANCE: The genus as a whole is distributed throughout the world from the Arctic Circle to 30° South. One or other species can be found throughout Africa and Madagascar. *Typha* species always occur in marshes or at stream and river sides either in mud or shallow water. They are especially troublesome as a constituent of sudd in the Nile and the Niger Delta. In recent years there have also grown up vast populations of *Typha* in the pseudodelta of the River Senegal which Professor Trochain tells me did not exist in 1933 when he visited these territories in the course of preparing his "Contribution à l'étude de la végétation du Senegal" (*Mém. IFAN, No. 2,* 1940). Elsewhere *Typha* colonies are of importance as they encroach on small dams and river sides. They also frequently serve as dormitories for *Quelea,* protect the larvae of mosquitoes from fish that feed on them and hinder the navigation of fishermen's boats. *Typha* is bound to become a problem in any newly constructed dams or irrigation systems. In Portugal *Typha* spp. are troublesome in rice cultivation.

CONTROL: There is little or no experience with chemical control in Africa, but in America the following treatments have been recommended: 12 lb. oil-based esters of 2, 4-D in 200 gallons water (spray new season's growth at 2 - 5 inches); 10 - 20 lb. acid equivalent/acre of amino-triazole or 20 lb. dalapon/100 gallons water/acre. Also in America when *Typha* occurs as a ricefield weed it is recommended that infestations be ploughed in spring and the roots and rhizomes exposed to the air for 3 - 4 days.

7. **Vossia cuspidata** (Roxb.) W. Griff. **Graminae**
Vossia, Hippo grass Tab. VI

DESCRIPTION: A very robust grass with floating or submerged culms often running for considerable distances and copiously rooting at the nodes; aerial part of stem stout, erect, up to 1 m. or even 2 m. tall. Leaf-sheaths tightly clasping the stem; ligule very short; lamina linear, tapering to a very acute point, up to c.80 cm. long by 2.5 cm. wide, scabrous or puberulous above, midribs broad and pale. Inflorescence of 1 - 6 pale-green or straw-coloured racemes on a short common axis or more or less digitate, 15 - 25 cm. long, disarticulating into cylindric joints c.1 cm. long. Sessile spikelets appressed to the rhachis, ovate or lanceolate-oblong; lower glume subulate-cordate with a tail occasionally reaching 2.5 cm. long, margin scabrous or minutely spine-toothed.

DISTRIBUTION AND IMPORTANCE: From Southern and Central Sudan southwards through tropical Africa to the Zambezi; also occurs in India from where it was originally described by Roxburgh, and in Indo-China. This is a troublesome weed in the canals of the Gezira scheme in the Sudan and one of the principal constituents of sudd in the Nile Valley in the Sudan and in the Niger Delta. It is reported to be a pioneer sudd species in Lake Bangweulu in Northern Rhodesia, being among the first plants to penetrate and eventually block navigation channels. It is also evident in the beginnings of sudd formation in Lake Kariba. It is grazed freely by both hippopotamus and cattle. As it is so widely spread in tropical Africa this weed will grow in importance with the development of new waterways, irrigation systems and dams.

Control: No information on the use of modern herbicides on Vossia appears to be available. Such herbicides as dalapon should probably be tried.

8. **Nymphaea caerulea** Savigny — **Nymphaeaceae**

Water-lily — Tab. VII

Description: A usually rather stout herb with a tuberous rhizome growing in the mud under water and the leaves on long petioles floating at the surface. Leaves rather leathery, 8 - 30 cm. long by 6 - 28 cm. wide, from orbicular to elliptic, base incised-cordate, peltate, basal lobes obtuse or acute, margin entire or slightly undulate near the base, upper surface smooth and dark green, lower surface green, purple or reddish, often blotched, nerves slightly raised. Flowers blue, pink or rarely white, 6 - 20 cm. in diameter. Sepals, usually 4, 3 - 8 cm. long. Petals 12 - 24, as long as the sepals. Stamens 30 - 100. Fruit 2 - 4 cm. in diameter, depressed globose, rather spongy, with many seeds. Seeds scarlet, 1.1 mm. long, ellipsoid with longitudinal lines of minute hairs.

Distribution and Importance: Described by Savigny from Egypt and is distributed southwards from there throughout tropical Africa. Also occurs in the Transvaal. A very common species of rivers, lakes and pools. It is an early colonizer of small or large dams but probably does not grow in water above about 3 m. deep. Together with *Potamogeton richardii* it is extremely troublesome in small farm dams. The leaves can cover the surface of a small dam in 2 - 3 years and reduce its efficiency alarmingly from a fish culture point of view as well as a source of drinking water or for irrigation purposes. This is the most harmful *Nymphaea* sp. in south tropical Africa but at low altitudes in this region and elsewhere in Africa it is often replaced in importance by *N. lotus* L., *N. capensis* Thunb. or *N. maculata* Schumach.

CONTROL: Under sound modern methods of fish culture involving fertilization of the water in fish ponds unicellular green algae are markedly encouraged and, possibly because of the resultant cutting off of light from the seedlings, *Nymphaea* spp. are not able to colonise such ponds. If the leaves are cut off the weed-eating fish *Tilapia melanopleura* can also keep *Nymphaea* under control. A kind of heavy steel rake with powerful downward pointing teeth arranged in an arc drawn over the muddy bottoms of small dams by a power winch or tractor can drag out the tubers and leaves on to the banks and has shown promise in removing *Nymphaea* and *Potamogeton richardii*. The use of herbicides against African *Nymphaea* spp. has had little or no success so far. *Nymphaea odorata*, an American species, has, however, recently been controlled by dosages of 0.5 - 5 p.p.m. kuron.

9. **Potamogeton richardii** Solms **Potamogetonaceae**
Pondweed Tab. VIII

DESCRIPTION: Herb with wiry stems rooting at the nodes and attached to the bottom of the stream or pond, etc. Leaves all floating or with a few submerged leaves which soon disappear and with elongated petioles varying with the depth of water. At the base of the petiole are a pair of elongated stipules not adnate to the petiole but forming an independent stipular sheath; lamina of floating leaves elliptic-oblong, subacute at the apex, cuneate to rounded at the base, rather leathery in texture, up to about 9 cm. long by 3.5 cm. wide; inflorescence a pedunculate, axillary spike with the flowers borne a little above water level. Floriferous portion of spike 2 - 4 cm. long, composed of many small greenish or brownish regular flowers with 4 free rounded shortly clawed perianth segments, four sessile broad anthers attached to the perianth segments and usually four free flask-shaped carpels each with a sessile stigma. Fruiting carpels 1 - seeded, indehiscent.

DISTRIBUTION AND IMPORTANCE: Described originally from Ethiopia it extends from Eritrea and the Sudan southwards through East Africa to the Rhodesias then westwards into Angola and the Eastern Congo. Also in the Transvaal and Cape Province. Together with *Nymphaea caerulea* this species is especially troublesome in small dams. Once again fish culture methods involving the fertilization of the water will prevent its spread. Also like *Nymphaea* it can be removed more or less successfully by mechanical raking or by ploughing of the bottom when the dam is drained. Two other African *Potamogeton* spp., *P. octandrus* Poir. (with small floating leaves) and *P. schweinfurthii* A. Benn. (with mostly submerged leaves) have a rather similar habit but are not so important probably from a weed point of view. *P. octandrus*, however, is somewhat troublesome in rice crops in Central Madagascar (for most recent taxonomic study see Dandy, J. E., The genus *Potamogeton L.* in Tropical Africa, *Journ. Linn. Soc., Bot.*, **50**: 507 - 540 (1937)).

CONTROL: There are no reports of the successful control of *Potamogeton* spp. with floating leaves from Africa and it is apparent that no great success has been achieved elsewhere either. *Potamogeton nodosus* Poir., a species similar to *P. richardii*, has been controlled in irrigation canals in America by applications of 10 gallons/cu. ft./second of rate of flow of 2, 3, 6-trichlorobenzoic acid and other aromatic solvents. In dams it has been controlled by 5 p.p.m. arsenic trioxide. In Portugal the control of *Potamogeton* spp. is successfully achieved by allowing the infested beds to dry out thoroughly.

2°. PLANTS TROUBLESOME IN IRRIGATED CROPS (i.e., RICE, ETC.), OFTEN SUBAQUATIC

10. Oryza perennis Moench **Graminae**
Wild rice Tab. IXa

DESCRIPTION: Coarse perennial herb up to 150 cm. tall; rooting at the nodes and spreading by means of an extensive system of branching rhizomes. Culms stout, ribbed. Leaves up to c.1.7 cm. wide, tapering gradually to the apex; ligules membranous and sometimes reaching 2 cm. long; leaf-sheath produced at the apex into a pair of acute auricles 5 - 6 mm. long. Panicle lax, 20 - 30 cm. long; spikelets reddish-yellow, oblong or oblong-elliptic, setulose mainly on the ribs and keels, up to 1.2 cm. long; awned from the apex of the fertile lemma, the awn up to 5 × the length of the spikelet.

DISTRIBUTION AND IMPORTANCE: Widespread from the Sudan (Equatoria) to the Northern Transvaal. Also in tropical America and Ceylon. It has been suggested as the ancestor of the cultivated rice plant. It is reported to be a harmful weed in irrigated soils in West Tropical Africa and Madagascar. It also provides, in various parts of Africa, an excellent fodder for cattle and makes good hay if cut green. It is also used as a green manure and occasionally as a grain food by Africans. This plant has often been known as *O. barthii* A. Chev. in Africa but Chatterjee has shown (in *Ind. Journ. of Agric. Sci.*, **18**, 3 : 185 - 192 (1948) and *Ind. Journ. Gen. and Pl. Breed.* **11**, 1 : 18 - 22 (1951)) that this name was based on a mixture of three species, *O. perennis* widespread in Africa, *O. brachyantha* A. Chev. & Roehr. from tropical West Africa and the Sudan and *O. breviligulata* A. Chev. & Roehr, also from tropical West Africa and the Sudan. He evidently looks on *O. barthii* as a *nomen confusum* as it is an earlier name than either *O. brachyantha* and *O. breviligulata* but he does not use it to replace either of them.

It is evident that *O. perennis* has potential danger as a weed of irrigated crops throughout tropical Africa.

CONTROL: Because of its close relationship to the cultivated rice it is naturally difficult to deal with in this crop. Selective weed-killers would be difficult to find and there are no satisfactory records of herbicidal treatments of this weed.

11. **Ischaemum rugosum** Salisb. **Graminae**

Tab. IXb

DESCRIPTION: Annual grass with culms erect or ascending, to 60 cm. tall, tufted, nodes glabrous or puberulous. Leaves with ligule short and truncate; lamina 10 - 15 cm. long by 0.4 - 1.2 cm. wide, rounded at the base. Inflorescence of 2 erect racemes 2.5 - 8 cm. long; spikelets 3 - 6 mm. long, stout and ciliate; lower glume of sessile spikelet cartilaginous and shining below the middle and crossed there by 3 - 5 deep convex smooth ridges.

DISTRIBUTION AND IMPORTANCE: Occurs in China, Malaya, Fiji Islands, India, Ceylon, West Africa, Madagascar and the Andaman Islands. It is an important weed in rice in India, Ceylon and the Fiji Islands. It is also of great importance as a weed of rice in the Lake Alaotra region of Madagascar and has recently assumed importance in irrigation ditches and ricefields in Ghana, Sierra Leone and Liberia. One of the factors that make it difficult to control is that in the young stages it is remarkably like rice in appearance. It is apparently quite palatable to cattle.

CONTROL: Very little literature appears to exist on the control of this weed but in Fiji it has recently been recommended (Mune, T. L. and Parham, J. W. (1957), *Agric. Journ., Fiji*, **3** and **4**: 54-55) that in cultivated areas the land should be left fallow during the growing period of the weed and ploughed or disked 5 or 6 times. In uncultivated areas 100 lb./acre TCA is recommended and for spot treatment 2 lb. TCA per gallon of water. The importance of weed-free rice seed is also stressed.

12. Cyperus esculentus L. **Cyperaceae**
Water grass Tab. IXc

DESCRIPTION: Glabrous herbaceous sedge up to c.60 cm. tall, roots fibrous and usually slender, stolons present with small tubers some distance from the crown; stem ribbed and 3-angled; tubers dull brown, when ripe c.1.2 cm. long and marked with concentric lines (nodes). Leaves basal, grass-like, to c.30 cm. long by 0.7 cm. wide, $\frac{1}{2}$ - $\frac{2}{3}$ the length of the stem, finely ribbed. Inflorescence a compound or simple umbel with 5 - 10 rays; rays up to 4 cm. long; spikes of 4 - 30 spikelets; spikelets usually golden- or yellow-brown, 6 - 30-flowered, 5 - 12 mm. long by 2 mm. wide; glumes strongly 7-nerved; style branches 3.

DISTRIBUTION AND IMPORTANCE: Widely distributed throughout the tropical, subtropical and warm temperate regions of the world including the whole of Africa and Madagascar. A very important weed of irrigated land and particularly of rice crops. The tubers are edible and sweet. They are, however, only cultivated for this purpose in the Mediterranean region. This weed is almost certain to become important in any area in which irrigation systems are practised. At present the following territories regard it as of major importance — Madagascar, South Africa, the Federation of Rhodesia and Nyasaland, Angola and Moçambique.

CONTROL: An extremely difficult weed to control and it is probable that a combination of methods will be needed in most cases. The following suggestions may be made:

(1) Use lime applications as acid soils encourage *Cyperus esculentus*.
(2) Plough with disks penetrating as deep as 25 cm. when the soil is as dry as possible, i.e., in the dry season.
(3) 2, 4-D amine at $\frac{3}{4}$ lb./acre (but herbicidal treatments are often not as successful as thorough ploughing in dry soil).
(4) For spot control soil injection with chlorinated hydrocarbons (i.e., DD) is effective.
(5) 0.5 lb. methyl bromide/100 sq. ft. as a fumigant. Air-tight covers must be used.
(6) 20 lb./acre CMU can be used as a soil sterilant.

13. **Cyperus rotundus** L. **Cyperaceae**

Tab. IXd

DESCRIPTION: Rather like *C. esculentus* but has a creeping rhizome often producing long rows of small leaf rosettes along the ground; the stolons are long, thin and woody and here and there swollen into black ellipsoid tubers; finally the glumes are more strongly keeled, only obscurely few-nerved and their colour is usually from rust to a rich chestnut-red.

DISTRIBUTION AND IMPORTANCE: Throughout the warmer regions of the globe as a weed of irrigated crops and in damp places. At least equal in importance as a weed to *C. esculentus*. In Southern Africa it appears to be of less importance at present than *C. esculentus* but it probably replaces or at least equals this species in importance in Egypt, the Sudan, Central African Republic, Chad, Congo (Brazzaville) and Gabon. In Madagascar both species are about equally important and it is also an important weed of sugar cane in Mauritius.

CONTROL: As for *C. esculentus* but it appears that deep cultivation of soils when dry is somewhat more effective in the case of *C. rotundus*. In areas where the weed is particularly troublesome it may be best to plant eucalyptus as has been recommended by J. Koechlin in the Niari Valley in the south of the Congo (Brazzaville) (Rapport de l'Office de la Récherche Scientifique et Technique d'Outre-Mer, Paris, 1951). In Madras 5 lb./acre of the sodium salt of 2, 4-D mixed with MCPA in diesel oil has given good results.

14. **Echinochloa stagnina** (Retz.) Beauv. **Graminae**

Tab. Xa

DESCRIPTION: Perennial grass usually with long creeping rhizomes; culms radiating from a central tuft, prostrate or floating at first for some distance, rooting at the nodes, then erect and up to 1.6 m. tall. Leaves sometimes with bars of purple colouring, glabrous except at the mouth and sometimes the lower nodes of the sheath; blades flat, tapering to a fine point, margins scabrid;

ligule a fringe of hairs. Inflorescence 8 - 25 cm. long of crowded spike-like racemes c.5 cm. long; spikelets 4 - 6 mm. long, conspicuously awned, light green, often tinged with purple; glumes and lower lemma minutely hairy and with longer rigid hairs on the nerves.

DISTRIBUTION AND IMPORTANCE: Throughout tropical Africa and in South Africa from the Eastern and Northern Cape northwards. Also in Madagascar. A very rich fodder grass with a high sugar content, often the food of the hippopotamus. Troublesome in rice cultivation in central and western Madagascar. Potentially this species is probably also a danger as a plant which encroaches on navigation channels and in fact is reported as such on the River Nyong, between Abong-Mbang and Mbalmayo in the Cameroon. It may also be of some importance in this respect in the Congo basin. Another species of *Echinochloa,* the pantropical *E. colonum* (L.) Link, which is a tufted annual up to 1 m. tall rooting from the nodes with no ligule and awnless or minutely awned spikelets, also occurs as a weed of rice crops in central and eastern Madagascar. *E. crus-galli* (L.) Beauv., another more or less widespread weed in the warmer regions of the world, is also a weed of rice crops in central and western Madagascar. This latter is an annual species also but the spikelets have a short awn or at least a cusp on the lower glume. *E. holubii* (Stapf) Stapf, a perennial up to 1 m. tall with awnless or minutely awned spikelets, is an important rice-field weed in Swaziland.

CONTROL: Apart from the normal methods of mechanical or hand removal the following herbicidal treatments have shown promise with *Echinochloa* spp.; 0.25 - 0.75 lb./acre kuron for *E. colona* (but this treatment will harm rice); 32 lb./acre CMU will control *E. colona* as a pre-emergence treatment without harming the rice; 2 - 3 lb./acre PCP can be applied to the rice in the spike stage when the rice shows no permanent harm but *E. holubii* and other grasses are killed (for further details see Parker, C. and Byers, D. S. The use of PCP for grass control in rice, pp. 92 - 98, *Proc. Afr. Weed Contr. Conf.*, 1958, publ. Fisons Pest Control Ltd., Saffron Walden).

In America *Echinochloa crus-galli* is controlled by submerging the rice seed to a depth of 4 - 6 inches immediately after sowing and keeping the land submerged until the rice crop is mature. Another method recommended in America is to flood the fields for a short period before sowing the rice so as to encourage the weed to germinate and then destroy it by ploughing. In Italy experiments on the biological control of this weed have been carried out using a smut fungus (*Sorosporium bullatum* Schr.) (Vasconcellos, 1954).

II. PLANTS PRESENTING A POTENTIAL DANGER

1°. PLANTS TROUBLESOME IN DAMS, RIVERS, IRRIGATION FURROWS, ETC.

(a) FREE FLOATING PLANTS

15. Azolla africana Desv. **Azollaceae**
Azolla pinnata var. *africana* (Desv.) Bak. Tab. Xb
Azolla

DESCRIPTION: Small floating fern up to c.2.5 cm. long, brownish or greenish; fronds 1 - 3-together, each frond deltoid with 3 - 5 pairs of alternate branches; from the branches hang very fine plumose roots. "Leaves" minute, short and clasping, more distant below, overlapping towards the branch apices. Sporangia sessile in the leaf axils, of two kinds, the larger containing some or many-stalked globose capsules, the smaller with a conical point and containing a single macrospore.

DISTRIBUTION AND IMPORTANCE: Widespread from Cape Province northwards and throughout tropical Africa. Its occurrence is, however, rather sporadic. It is considered a pest of some importance in the Colesberg area of the Cape Province and is reported to cover lakes in the Congo (Brazzaville) in the Boko-Songho area. Another African species *A. nilotica* Decn. is widespread from Moçambique and South West Africa northwards to the Sudan but it has never been considered harmful so far. Finally, *A. pinnata* R. Br. grows in ricefields in western Madagascar but is not considered harmful.

CONTROL: In Portugal *Azolla caroliniana* Willd. in ricefields is removed when necessary by raking the water surface.

16. Lemna spp. **Lemnaceae**
Duckweeds Tab. Xc

DESCRIPTION: Minute floating aquatic flowering plants without distinct stems or real leaves but consisting of usually floating, leaf-like, ovate, elliptic or more or less orbicular thalli, 1 - several millimetres in diameter, either separate or cohering two or several together by their edges and having one or more minute rootlets growing downwards from their lower surfaces. Vegetative reproduction by the growth of further thalli out of the original ones. Inflorescences produced rather rarely, minute, borne in a pocket in the edge of the thallus upper surface and consisting of a 1-locular ovary with 1 or more ovules and 1 or 2 stamens enclosed in a minute spathe.

DISTRIBUTION AND IMPORTANCE: Distributed throughout the world. In Africa the most widely distributed species and most important from our point of view are probably *L. perpusilla* Torr. (*L. paucicostata* Hegelm. ex Engelm.) which occurs throughout Africa and Madagascar, and *L. aequinoctialis* Welw. from the Sudan southwards to the Bechuanaland Protectorate and Southern Rhodesia. These plants form a scum on pans, ponds and dams and have general nuisance value because of this, although in Africa they are rarely considered to be seriously harmful. In Portugal several species are troublesome in rice cultivation.

CONTROL: Simazin at 0.6 gr./sq. metre has been used successfully in India and 5 p.p.m. diuron has been used successfully against *L. minor* L. in the United States. In Portugal *Lemna* spp. are usually removed from rice-fields by rakes.

17. Wolffia arrhiza (L.) Hork. ex Wimm. **Lemnaceae**
Tab. Xd

DESCRIPTION: Minute rootless floating flowering plants. Thallus ovoid to ellipsoid, 0.5 - 1 mm. long, reproducing vegetatively by budding off new thalli from one end. In temperate regions at least the thallus sinks to the bottom in winter. Flowers rarely observed, borne in a hollow on the upper side of the thallus; anther solitary, globose, sessile; ovary of a single ovule; sheath absent.

DISTRIBUTION AND IMPORTANCE: More or less cosmopolitan, absent in the coldest regions, often very local. Widely distributed in Africa and Madagascar but not often collected. Considered a harmful weed in South Africa. In Kenya (Kavirondo) water infested with *Wolffia arrhiza* has been strongly suspected of tainting coffee. In Portugal this species occurs as a weed in ricefields.

CONTROL: Has been controlled in India by 0 - 6 gr./sq. metre simazin. When agglomerated into masses in ricefields, can be removed by raking.

18. **Trapa natans** L. — **Trapaceae**

Water chestnut — Tab. XIa

DESCRIPTION: Annual aquatic floating herb. Leaves alternate, floating and produced in a rosette from the upper nodes; petiole very variable in length, spongy and inflated near the middle; lamina deltoid or rhombic, often somewhat broader than wide, 1.5 - 4.5 cm. long by 1.5 - 7 cm. wide, toothed except at the base, glabrous above, usually more or less hairy below. Below water level the leaves are replaced by green feathery adventitious roots (? or submerged leaves) in pairs on either side of the leaf scars; root segments filiform. Flowers regular, solitary in the upper axils on pubescent peduncles, about as long as the nearby petioles. Sepals, petals and stamens 4. Sepals lanceolate, 4 - 7 mm. long. Petals white, obovate-oblong to obovate, 8 - 18 mm. long. Fruit 3 - 6 cm. across (including horns), 1-seeded, top-shaped, very hard, 2 or 4-horned, horns up to 2 cm. long.

DISTRIBUTION AND IMPORTANCE: In Africa from Portuguese Guinea, Sudan, Uganda, Tanganyika, Angola, Nyasaland, Rhodesia as far south as the Zambezi, Moçambique and Natal. Also in Europe, Asia, North Africa as an indigenous plant. Naturalized in North America and Australia. Not a serious danger at present in any part of Africa but is looked upon as a weed of some importance in the Danube (Rumania). The fruit is edible and is cultivated in China.

CONTROL: Hormone weed killers of the 2, 4-D type have given moderately good control.

19. Ceratophyllum demersum L. **Ceratophyllaceae**
Hornwort Tab. XIb

DESCRIPTION: Submerged perennial herb. Leaves whorled, up to c.4 cm. long but usually less, twice or thrice forked with linear-subulate segments, edges of segments more or less toothed. Flowers very small, sessile in the axils of the leaves, each surrounded by minute bracts, lacking a real perianth. Female flowers with a minute ovary and simple style. Fruit oblong-ovoid, more of less compressed, c.5 mm. long, with two short horns near the base, 1-seeded.

DISTRIBUTION AND IMPORTANCE: An almost cosmopolitan aquatic herb. Widespread in Africa. When sterile very like a *Najas* sp. but distinguished by its divided leaves. Not so far considered troublesome in Africa but is often so elsewhere and the development of water systems in Africa may mean that attention will have to be given to its control in Africa also.

CONTROL: The following treatments have given successful control:—

(1) 5 p.p.m. sodium arsenite (calculated as arsenic trioxide).
(2) 1 p.p.m kuron.
(3) 10 - 20 p.p.m. monuron.
(4) 5 - 10 p.p.m. diuron.

(b) PLANTS ROOTING IN MUD (FIXED PLANTS)

20. Chara spp. **Characeae**
Stoneworts Tab. XIc

DESCRIPTION: Submerged aquatic algae growing in the mud at the bottom of bodies of still or relatively slow-moving water. The plant consists of very slender green stems bearing smaller branchlets in whorls. The branchlets are again repeatedly digitately divided and so form dense masses of branchlets at the main nodes. The whole plant may be from c.2 - 12 cm. tall and is rough to the touch because of small spine cells; the individual branchlet cells are finely longitudinally lined. The sexual system consists of free-swimming flagellate male cells or spermatozoids produced in minute antheridia borne at the base of the groups of branchlets. In *Chara* the oogonium or female organ is borne above the antheridia. The oogonium is ellipsoid as a rule in shape and has a wall made up of spirally arranged cells with a crown of 5 small cells in one tier at its apex. When fertilized the single-celled oogonium becomes an oospore which can later germinate and produce a new plant. The ripe oospore is of the order of 0.5 mm. in length.

DISTRIBUTION AND IMPORTANCE: The *Characeae* have a world-wide distribution and species of *Chara* are widely distributed in Africa. Almost as common are species of another genus, *Nitella*, which are not harsh to the touch and whose vegetative cells are not longitudinally lined. In *Nitella* the crown of cells at the apex of the oogonium are 10 in number and are in 2 tiers. *Nitella* species are very palatable to vegetable feeding fish such as *Tilapia melanopleura* and may be planted in fish breeding ponds, although anglers sometimes complain of the way *Nitella* gets caught up in their tackle. *Chara* spp. are probably somewhat less palatable but are nevertheless eaten fairly readily. They only become troublesome where their growth impedes the flow of irrigation channels or fills small storage dams.

CONTROL: In small dams and irrigation ditches they are easily controlled by the introduction of *Tilapia melanopleura* or other vegetarian species of *Tilapia.* Otherwise, as these plants are very tender, mechanical methods can fairly easily keep *Characeae* under control. 1 - 4 lb. copper sulphate/million gallons water is also reported to give good control. For a bibliography of the *Characeae* in general see R. D. Wood (1952), *The Characeae*, 1951, Bot. Rev., **18**, 5: 339 - 353. For the taxonomy of African species, see Braun, A. (1868), *Die Characeen Afrika's* Monatsber. König. Akad. Wiss. Berl. **1867**: 782 - 800, 873 - 944; Feldmann, G. (1946), *Les Charophycées d'Afrique du Nord*, Bull. Soc. Hist. Nat. Afr. Nord, **37**: 64 - 18 and Groves, J. and Stephens, E. L. (1926), *New and Noteworthy S. Afr. Charophyta* I, Trans. Roy. Soc. S. Afr., **13**: 145-158; (1933), **21**: 271-289. For Madagascar see Grove, J. (1928), *On Charophyta Collected by T. B. Blow in Madagascar*, Journ. Linn. Soc., Bot. **48**: 125 - 137.

21. **Marsilea** spp. **Marsileaceae**

Tab. XId

DESCRIPTION: Small herbaceous ferns, aquatic or growing in mud; rhizomes slender and wide-creeping, sometimes hairy; fronds of four fan-shaped leaflets looking like clover leaves and clustered at the ends of erect stems up to several inches tall. Spores produced in hard bean-shaped sporocarps borne on short stems arising in the angles of the leaf-stalks and rhizomes. The ripe sporocarp opens in water and releases a gelatinous mass in which are embedded the sori containing the spores.

DISTRIBUTION AND IMPORTANCE: Widely distributed through the whole world including Africa and Madagascar. The South African species are sometimes considered important as weeds. In Portugal the European species *M. quadrifolia* L. occurs as a weed in ricefields.

CONTROL: The European species *M. quadrifolia* is resistant to 2, 4-D. It may be controlled by drying out the fields till the rhizomes are killed.

22. **Microlepia speluncae** (L.) T. Moore **Dennstaedtiaceae**

Tab. XIIa

DESCRIPTION: Large fern growing in clumps from short rhizomes with hair-like brown scales; stipes of fronds straw coloured, 30 - 60 cm. long, rough, with short tuberculate hairs. Fronds large, c.1.3 m. tall by 0.6 m. wide, ovate or ovate-lanceolate, hairy on both sides, tripinnate or tripinnatifid. Pinnae alternate, lanceolate, wide at the base, almost sessile. Pinnules sessile, 2 - 5 cm. long, 1.2 - 1.8 cm. wide, cut to or to near the midrib into oblique, rounded, crenate or lobed segments with a sorus below each sinus. Sori within the margin with a thin, cup-shaped indusium opening outwards and attached at the base and sides.

DISTRIBUTION AND IMPORTANCE: Widespread in Africa and throughout the Old World. A species of damp forest or swamps. Reported as somewhat troublesome in Bechuanaland Protectorate.

CONTROL: No information available.

23. Ottelia ulvifolia (Planch.) Walp. **Hydrocharitaceae**
Water lettuce Tab. XIIb

DESCRIPTION: Submerged aquatic herb with fibrous roots growing in mud. Leaves in a basal rosette, membranous, elliptic-lanceolate to oblanceolate, acute at the apex, narrowing to the base, up to c.3 cm. long by 6 cm. wide. Flowers emerging above the water from a compressed, narrowly ellipsoid, green spathe up to c.5 cm. long and narrowly winged at the 2 margins. Petals 3, obovate, very delicate and soon withering, yellow or white; stamens 6; styles 6, bifid, hairy. Fruit, more or less, filling the slightly expanded spathe, 1-locular and many-seeded.

DISTRIBUTION AND IMPORTANCE: Widespread through Africa from Ethiopia and the French West African territories southwards to Moçambique, Southern Rhodesia, Northern Transvaal, South West Africa and Bechuanaland; also in Madagascar. Not considered especially troublesome at present but an important constituent of dams and slow-moving waterways throughout its range. In clearing small dams, etc., its eradication needs to be taken into account.

CONTROL: No literature available.

24. Vallisneria aethiopica Fenzl **Hydrocharitaceae**
Tab. XIIc

DESCRIPTION: Submerged stoloniferous herb with fibrous roots growing in the mud; leaves grass-like, more or less radical, linear, up to c.40 cm. long, obtuse at the apex, margins usually minutely denticulate, longitudinally veined and with obscure transverse veinlets. Flowers unisexual; males minute, numerous in a tubular, 2-toothed shortly pedunculate spathe; female flowers solitary in a narrow spathe borne on a long filiform peduncle which becomes spirally twisted after fertilization; perianth with 3 minute lobes and a slender tube c.1 cm. long; stigmas 3, bilobed. Fruit narrowly cylindric, many seeded.

DISTRIBUTION AND IMPORTANCE: Widely distributed in tropical Africa from the Sudan to Southern Rhodesia and has been recorded as an introduction in South Africa. Not regarded as a troublesome weed but often grows densely in relatively slow-running rivers. The rather more robust but closely related *V. spiralis* L. which occurs in the Mediterranean region is commonly cultivated in aquaria and care should be taken to see that it does not become introduced into African rivers.

CONTROL: *Vallisneria spiralis* can be controlled by 400 lb./acre copper sulphate or 5 p.p.m. sodium arsenite.

25. **Typhonodorum lindleyanum** Schott — **Araceae**

Mgombakofi (Zanzibar) — Tab. XIId

DESCRIPTION: Giant aroid with a large thickened rootstock and with a thick banana-like stem up to 2 m. tall with its base in water. Leaves on long stout petioles; lamina up to c.1 m. long, apiculate at the apex, sagittate at the base, margin undulate. Spathe typically arum-like on a peduncle 25 - 35 cm. long, whole spathe 50 - 80 cm. long, tube of spathe c.7 cm. long, lamina of spathe whitish, oblong-lanceolate, acuminate, up to 15 cm. wide. Spadix c.$\frac{3}{4}$ the length of the spathe with small female and male flowers at the base and a sterile horn-like portion above c.20 cm. long. The spathes bend over in fruit and produce many flattish brown seeds c.2.5 cm. in diameter.

DISTRIBUTION AND IMPORTANCE: Occurs in the Islands of Zanzibar, Pemba and Madagascar. Its habitat is in undeveloped fresh water swamps and if these require to be cleared the plant is reported from Zanzibar to be extremely difficult to eradicate. Its importance as a weed is at present potential rather than serious. It is not considered important in Madagascar. The roots and seeds are edible but the latter are poisonous unless repeatedly boiled and the water discarded.

CONTROL: No special information available.

26. **Alisma plantago-aquatica** L. **Alismataceae**
Water plantain Tab. XIIIa

DESCRIPTION: Perennial aquatic herb up to 1 m. tall, rooting in mud; rhizome tuberous, becoming almost bulbous by the thickening of the sheathing leaf-bases. Leaves all radical on long petioles; lamina ovate, subcordate at the base, subacute to acuminate, 3 - 7-nerved from the base, 8 - 20 cm. long, first leaves very reduced. Inflorescence a much-branched, verticillate panicle borne on a stout stalk or scape; scapes 1 - several, erect or curved. Flowers c.1 cm. in diameter, pink or pale lilac. Perianth segments in 2 rows of 3, outer oblong, inner obovate-circular. Stamens 3, 6 or more. Carpels c.20, free, 1 - ovulate. Fruiting carpels in a more or less flattened head or whorl.

DISTRIBUTION AND IMPORTANCE: Widely distributed in Europe and Asia. Also in Australia and New Zealand. It occurs as an introduction in Chile and a distinct subspecies occurs in North America. In Africa, it is recorded from North Africa, Eritrea, Ethiopia, Congo (Leopoldville), Uganda, Ruanda-Urundi, Kenya, Tanganyika and Moçambique. In South Africa, it occurs in the Transvaal and Orange Free State and is considered a harmful weed. It is a ricefield weed in Portugal and America.

CONTROL: In Portugal flooding of ricefields before cultivation is recommended as well as sowing the crop densely. In America 1.5 - 3 kg. per hectare 2, 4-D has given satisfactory control.

27. **Aponogeton desertorum** Zeyh. **Aponogetonaceae**
ex Spreng.
Aponogeton kraussianus Hochst. ex Krauss
Tab. XIIIb
Dog with two tails

DESCRIPTION: Aquatic plant with tuberous rootstock growing in mud. Leaves leathery, floating, long-petioled, oblong, usually 7 - 15 cm. long by 5 - 7.5 cm. wide, apex subacute or rounded, base rounded or subcordate, 7 - 9 -

nerved from the base, medium nerve with 3 distinct parallel ridges. Inflorescence borne just above water level on a long peduncle, consisting of a 2-branched spike of small yellow flowers, the 2 arms of the inflorescence diverging like the arms of a lyre, 2-7 cm. long. Stamens 6, exceeding the 3 perianth segments. Ovary of 3-6 free utricular carpels. Fruit of c.1-3 hardened, beaked, ovoid follicles, many seeded.

DISTRIBUTION AND IMPORTANCE: From Cape Province northwards to Angola in the west and Ethiopia, Eritrea and Somaliland in the east. It is likely that *A. holubii* Oliv. from Bechuanaland and *A. eylesii* Rendle from Rhodesia are no more than forms of this widespread species. In tropical West Africa and the Sudan *A. subconjugatus* Schumach. with more elongate-oblong leaves is widespread and probably plays a similar ecological role.

In Southern Africa *A. desertorum* infests small dams and in association usually with *Potamogeton richardii* and *Nymphaea caerulea* its leaves rapidly spread over their surfaces. It is on the whole a relatively less vigorous plant than either of these two species and is consequently somewhat less important as a weed.

In Central Madagascar another species *A. ulvaceus* Bak. is reported as a weed of ricefields. Its inflorescence is similar to that of *A. desertorum* but its leaves are much larger, submerged, more membranous, oblong-elliptic, undulate at the margins and cuneate at the base.

CONTROL: The same methods as those given for *Potamogeton richardii* and *Nymphaea caerulea* are recommended for *Aponogeton desertorum*.

28. Najas spp. — **Najadaceae**

Saw weeds, Naiads — Tab. XIIIc

DESCRIPTION (there are 16 species of *Najas* in Africa and the Mascarenes [including Madagascar]): Many botanical taxonomists hesitate to name them with certainty but the commonest species for our present purpose are probably *N. marina* L. (not confined to marine waters in spite of its name), *N. pectinata* (Parl.) Magnus, *N.*

interrupta K. Schum. and *N. welwitschii* Rendle (for the most recent taxonomic treatment see H. Horn af Rantzien in Kew Bull., **1952**: 29 - 40). Submerged aquatic herbs with slender stems rooting at the lower nodes and growing on the bottom of pools and streams. Leaves either opposite or in whorls of 3, sometimes falcate, sessile with a sheathing often auriculate base, auricles toothed or entire; leaf-lamina linear and with the margins toothed or rarely entire. Flowers monoecious or rarely dioecious, very small and usually hidden in the leaf axils, ebracteate or with a spathaceous bract. Male flowers with a spathaceous perianth and 1 stamen; anther sessile, 1 - 4 - locular. Female flowers consisting of a 1 - locular flask-shaped ovary, a 2 - 5 - fid style, ebracteate or with a spathaceous bract. Fruit of one small seed usually embraced by the leaf sheath, indehiscent.

DISTRIBUTION AND IMPORTANCE: *N. marina* (with internodes and dorsal side of leaves spinose) in North Africa, Uganda, Congo (Leopoldville), Eastern Cape and Natal, Sicily, Middle East, Tropical Asia and Australia; *N. pectinata,* throughout Africa and Madagascar; *N. interrupta* from Tanganyika to the Transvaal and Natal, and *N. welwitschii* from Angola, Bechuanaland Protectorate and Southern Rhodesia. Widespread in streams, pools and dams but it is in irrigation canals and furrows that *Najas* spp. cause most trouble by gradually reducing the flow of water. Few cases of serious trouble from this cause have been reported so far but the irrigation furrows and canals of one large sugar estate in Southern Rhodesia are badly affected. *N. minor* All. is a ricefield weed in Portugal.

CONTROL: In dams can be controlled by introduction of the weed-eating fish *Tilapia melanopleura* which of course serves a useful purpose by turning its vegetable food into edible flesh. Nothing definite is known regarding the use of herbicides against *Najas* in Africa but 5 p.p.m. arsenic trioxide is used against this type of submerged weed, including other *Najas* spp., in America. Also in America aromatic solvents such as 2, 3, 6 - trichlorobenzoic acid at rates of 10 gall./cu. ft./sec. of flow in the channel applied for 30 minutes gives good control of submerged growth generally in irrigation channels. If future research becomes necessary in Africa it should probably follow along these lines. As a weed in Portuguese ricefields *N. minor* is controlled by drying out the fields for a few days.

29. **Lagarosiphon** spp. **Hydrocharitaceae**

Tab. XIIId

DESCRIPTION: Submerged aquatic herbs very similar to *Elodea*. Stems elongate and branched, rather tender. Leaves crowded and alternate, subopposite or whorled, sessile, linear and often tapering to the apex, margins minutely serrate or more or less entire. Flowers enclosed in spathes in the axils of the upper leaves. Male flowers in clusters in an ovoid spathe; perianth of 2 sepals and 3 petals, c.3 mm. in diameter; stamens 3; staminodes 3, just exserted from the spathe at anthesis. Female flowers similar but enclosed in a narrow spathe; gynoecium very elongated (up to several cm. long); stigmas 3; ovules many.

DISTRIBUTION AND IMPORTANCE: There are about 13 African species and at least one, *L. madagascariensis* Casp., in Madagascar. In Africa the species with the widest distributions appear to be *L. muscoides* Harv. which occurs in South Africa and Southern Rhodesia; *L. major* (Ridl.) Moss in South Africa and Southern Rhodesia, and *L. schweinfurthii* Casp. from the Sudan to South West Africa. *L. major* is looked upon as a weed of some importance in dams in Southern Rhodesia and as the various species have a habit of growth and ecology very similar to *Elodea canadensis* they may have some potential importance throughout Africa and Madagascar.

CONTROL: No literature available.

30. **Scirpus cubensis** Poepp. & Kunth **Cyperaceae**

Tab. XIVa

DESCRIPTION: A perennial sedge, often stoloniferous or the base of the stem decumbent and rooting at the nodes; culms up to 1 m. tall, stout, trigonous near the top. Leaves grass-like, as long as the stems, up to c.1 cm.

wide. Inflorescence a simple umbel with 4 - 12 branches up to c.6 cm. long, bracts 5 - 10, leaf-like, up to 25 cm. long. Heads of spikelets brown, stellate-globose, c.1.2 cm. in diameter. Spikelets very numerous, up to c.6 mm. long, many flowered. Glumes ovate, spreading, rigid, acuminate, margins ciliate, turning outwards in all directions, 3 - 4 mm. long. Hypogynous bristles absent. Nutlet up to $\frac{2}{3}$ the length of the glume, narrowly obovoid, plano-convex, with a hardened conical beak; style branches 2.

DISTRIBUTION AND IMPORTANCE: From Mexico to Paraguay in America and widespread in tropical Africa. Also occurs in Madagascar. Has recently become important as one of the first species to colonize mats of *Salvinia auriculata* in Lake Kariba (Rhodesia) and so form sudd. Also known as a sudd plant in Northern Rhodesia and the Congo (Leopoldville).

CONTROL: No literature available.

31. Scirpus fluitans L.

Cyperaceae
Tab. XIVb

DESCRIPTION: Weak aquatic perennial sedge, sometimes rooting in the mud but often free floating; stems slender, compressed. Leaves inserted at intervals along the stem, linear, up to 5 cm. long. Inflorescence of solitary spikes terminal at the ends of the stems and not subtended by an elongated leaf-like bract, c.3 mm. long, ovoid, 3 - 5 - flowered, glumes pale greenish or pale brownish. Anthers 2; style 2 - branched; nutlet pale.

DISTRIBUTION AND IMPORTANCE: Western Europe, Mediterranean region, Asia, Australia and Africa. Widespread through Africa although it has not so far been found in Egypt and the Sudan. It is also common in Madagascar and Mauritius. Not important at present but could become troublesome in small dams or irrigation channels.

CONTROL: No information available.

32. Phragmites mauritianus Kunth **Graminae**
Reed grass Tab. XIVc

DESCRIPTION: Perennial grass with a stout creeping rhizome sometimes up to 10 m. long, rooting at the nodes; culms erect, occasionally up to 6 m. tall, lower part occasionally reaching 4 cm. in diameter, bamboo-like, many noded, sometimes branching. Leaf-sheaths overlapping; ligule densely ciliate; lamina tapering to a pungent apex, up to 90 cm. long and 4.5 cm. wide. Inflorescence a large greenish, purplish or pale brownish panicle, up to 70 cm. long by 30 cm. wide; branches clustered. Spikelets c.12 mm. long, covered with silky hairs.

DISTRIBUTION AND IMPORTANCE: Throughout tropical Africa. Also in Egypt and South Africa (but not in Cape Province), Madagascar and the Mascarenes. The rhizomes often run for considerable distances over or through water and by this means it encroaches on streams, dams and rivers. Together with *Typha* it also renders *Eichhornia crassipes* eradication much more difficult by making these plants more difficult to spray and find. The cosmopolitan species *P. communis* Trin. is also widespread in Africa but not so common as *T. mauritianus* except perhaps in South Africa. This latter species is of importance as a weed in many parts of the world, particularly in America.

CONTROL: *P. communis* has been successfully controlled by the following treatments:—

(1) 120 lb./acre TCA on terrestrial sites only.

(2) 20 - 40 lb./acre CMU.

(3) 5 - 10 lb./100 galls. water } dalapon
25 - 60 lb./acre

This latter material is best applied up to 20 weeks after burning off aerial growth or some 9 weeks after cutting down aerial stems. Applied in this way it has also shown promise in Southern Rhodesia in the control of *P. mauritianus.*

33. Myriophyllum spicatum L. **Haloragaceae**
Parrot's feather Tab. XIVd

DESCRIPTION: Submerged aquatic herb with rhizomes growing in the mud and elongated leafy shoots sometimes reaching 2.5 m. in length and naked below through decay of leaves. Leaves in whorls of 4 (rarely 3 or 5), 1.5 - 3 cm. long, more or less as long as the internodes, pinnate with 13 - 35 filamentous segments; rhachis also filamentous. Flowers in terminal spikes carried above the water, upper flowers male, the lower female, in whorls of 4 in the axils of bracts the upper of which are entire and shorter than the flowers, the lower larger and more or less divided. Calyx inconspicuous, petals 4, dull red, up to 3 mm. long. Stamens 8. Fruit subglobose, 4 - lobed, separated into 1 - seeded nutlets.

DISTRIBUTION AND IMPORTANCE: Almost cosmopolitan but apparently absent from Australia, Central and South America and much of tropical Africa. In Africa it is known from Algiers, Cape Province, Natal, Orange Free State, the Transvaal, Southern Rhodesia (Zambezi River) and Northern Rhodesia (Kafue River, Southern Province). It is looked upon as a serious weed in South Africa and is very dense in parts of the Kafue River. As it apparently thrives in the Kafue River, which is well within the tropics, it would be potentially harmful presumably if introduced to any part of tropical Africa. It occurs as a ricefield weed in Portugal.

CONTROL: Herbicidal methods suggested for *Myriophyllum* spp. are:—

(1) quick breaking emulsion of 2 - 4 lb./acre 2, 4-D (ethyl ester).

(2) 2.5 - 4 p.p.m. arsenic trioxide (applied as sodium arsenite).

(3) 15 lb./acre phygon XL.

(4) 0.5 - 2 p.p.m. kuron.

In ricefields it can be controlled by merely allowing the fields to dry out.

34. Ludwigia adscendens (L.) Hara **Onagraceae**
Jussiaea repens L. Tab. XVa
Water primrose

DESCRIPTION: Aquatic or subaquatic herb with long horizontal stems rooting in the mud or sometimes free floating; nodes often with long fibrous roots and sometimes with spindle-shaped, pale pink, hairy floats or vesicles. Leaves alternate, linear-oblanceolate to elliptic, obtuse or subacute at the apex, narrowed at the base into a short petiole, margins entire or slightly sinuate, glabrous or nearly so, up to 10 cm. long by 1 cm. wide. Flowers bright yellow, solitary, axillary or peduncles about as long as the ovary. Ovary inferior, more or less cylindric, often somewhat curved, surmounted at the apex by 5 oblong-lanceolate calyx lobes. Petals 5, obovate, c.1.2 cm. long. Stamens 10. Ripe capsule cylindric, c.3 cm. long, sulcate, slightly hairy or glabrescent, 5-locular and with many small seeds.

DISTRIBUTION AND IMPORTANCE: The African plant is distinguished as a variety, var. *diffusa* (Forsk.) Hara. It is widespread in the Near East and in Africa whilst other varieties occur in tropical Asia and America. The only territories in Africa that have so far reported some degree of harm caused by this weed are Angola and Moçambique where it is troublesome in irrigated crops, Bechuanaland Protectorate where it is partly responsible for closing navigation channels in the Okovango Swamps and in Mauritius. It is also appearing as a constituent of sudd in Lake Kariba and it may be that it is as a sudd plant that its greatest potential danger lies. Another *Ludwigia* of semiaquatic habitats, *L. pubescens* (L.) Hara var. *brevisepala* (Brenan) Hara (*Jussiaea suffruticosa* L. var. *brevisepala* Brenan) is reported to be troublesome in Gambia. *Ludwigia palustris* (L.) Elliot which occurs in Europe, Western Asia, America, North Africa, South Africa, Southern Rhodesia and Angola is a ricefield weed in Portugal.

CONTROL: No literature has been found on the eradication of this plant in Africa but the American variety has been controlled by 2 lb./acre 2, 4-D (dimethylamine and iso-octyl), MCPA (amine) and 2, 4, 5-TP (butyl ester).

35. Nymphoides indica (L.) Kuntze **Menyanthaceae**
Nymphoides thunbergiana (Griseb.) Tab. XVb
Kuntze
Water gentian

DESCRIPTION: Perennial aquatic herb with a smallish rootstock bearing a number of rather thick roots buried in the mud. Leaves leathery, floating, alternate, borne on long stems or runners having the appearance of petioles; lamina orbicular with a deep sinus reaching to the insertion of the petiole, up to c.12 cm. in diameter, rather pale green above, purplish or brownish spotted below, nerves not prominent. Flowers in a cluster of 10 - 25 on the apparent petiole a little way below the leaf-lamina; pedicels of varying lengths, up to c.5 cm. long. Flowers open one at a time just above water level, star-like from above, with 5 lanceolate-oblong sepals c.5 mm. long. Corolla white or yellow with a short tube having 5 tufts of hairs above the middle and 5 oblong-lanceolate lobes up to c.1.0 cm. long, the lobes carry long white or yellow hairs on the inner face. Fruit a 1 - locular globose capsule c.6 mm. in diameter; seeds many, compressed-globose, smooth.

DISTRIBUTION AND IMPORTANCE: Throughout tropical and South Africa; also in Asia, Australia and the Fiji Islands. A common plant that, with *Nymphaea caerulea* and *Potamogeton richardii*, encroaches on small dams in these regions. It does not spread quite so vigorously as these species and is correspondingly less important.

CONTROL: See *Nymphaea caerulea.*

2° PLANTS TROUBLESOME IN IRRIGATED CROPS (i.e., RICE, ETC.), OFTEN SUBAQUATIC

36. **Sagittaria guayanensis** Kunth — **Alismataceae**

Lophotocarpus guayanensis (Kunth) Dur. & Schinz

Tab. XVc

DESCRIPTION: Aquatic herb rooting in mud, juice milky. Leaves radical; lamina floating, ovate with rounded apex and deeply cordate base, 1.5 - 6.5 cm. long (along the midrib) by 2.5 - 10.5 cm. wide (submerged linear or lanceolate leaves sometimes present), nerves 15 - 17, prominent below; petiole 15 - 30 cm. long, ribbed and with air channels. Flowers in whorls of 2 - 3 in racemes on floating peduncles; upper whorls with male flowers, lower bisexual; pedicels up to 1 cm. long, recurved after fertilization. Perianth segments 6, in 2 rows, 3 inner ones petal-like, white with a purple spot near the yellowish base, obovate to orbicular, 12 - 15 mm. long. Stamens in hermaphrodite flowers 8 - 12, 6 - 10 in male flowers. Carpels very numerous.

DISTRIBUTION AND IMPORTANCE: tropical Africa in the Gambia, Mali, Sudan and Nigeria. Also in Madagascar, Malaysia, Formosa and tropical America. A ricefield weed in Malaysia and therefore of potential importance in similar conditions in Africa and Madagascar. A South American species, *S. montevidensis* Cham. and Schlecht. has been introduced to Tanganyika (at and near Amani in the East Usambaras) but apparently shows no signs of spreading.

CONTROL: No literature available.

37. **Cyperus difformis** L. **Cyperaceae**

Beandoha (Madagascar) Tab. XVd

DESCRIPTION: Annual sedge up to 75 cm. tall; culms tufted, triquetrous and slightly winged, rather tender. Leaves radical, up to $\frac{2}{3}$ the length of the culm, 3 - 5 mm. wide. Inflorescence a simple or compound umbel; bracts 2 - 4, up to 15 cm. long, similar to the leaves. Spikelets 3 - 8 mm. long by 1 mm. wide, many together in dense subglobose heads c.1 - 1.5 cm. in diameter, brown, 10 - 30 - flowered. Glumes in 2 opposite rows, closely packed, concave, very obtuse, 0.75 mm. long. Stamens 1 or 2. Nutlet yellowish brown, ellipsoid, almost as long as the glume; style branches 3.

DISTRIBUTION AND IMPORTANCE: Widespread in Southern Europe, Asia, Central and North America, the whole of Africa, Madagascar, Mauritius and Reunion. A species of small pools, river banks and swamps. A troublesome ricefield weed in Madagascar.

CONTROL: In the Philippines it has been found that *C. difformis* infestations can be decreased by increasing the depth of flood water. In Portugal it is recommended that the rice crop be sown densely. Treatment with 1 - 2 per cent 2, 4-D has also shown some success.

38. **Cyperus digitatus** Roxb. **Cyperaceae**

Tab. XVIa

DESCRIPTION: A robust perennial sedge up to c.2 m. tall with a very short woody rhizome and a mass of fibrous roots; culm 3 - angled near the top with concave faces (in subspecies *auricomus* (Sieber ex Spreng.) Kukenth. but not in subspecies *digitatus*). Leaves $\frac{3}{4}$ the length of the culm, up to 1.5 cm. wide. Inflorescence a large compound umbel; bracts 5 - 7, like the leaves, the longer exceeding the umbel; umbel with 6 - 10 main branches up to 18 cm. long; spikelets spreading almost at right-angles in clusters of 4 - 7 spikes up to 6 cm. long, c.10 mm. long by 1 - 1.5 mm. wide. Glumes straw coloured, in 2 opposite rows but not very compressed, cuspidate, c.1.5 mm. long. Nutlet oblong-ellipsoid, up to $^{3}/_{5}$ the length of the glume; style branches 3.

DISTRIBUTION AND IMPORTANCE: Widely distributed in the tropics and subtropics. Subspecies *auricomus* is widespread in tropical Africa but less common in South Africa. This subspecies grows along river banks in pools and swamps with its base often submerged. It is considered a weed of potential importance in irrigated crops in the Gambia.

CONTROL: No literature available.

39. **Pycreus mundtii** Nees — **Cyperaceae**

Cyperus mundtii (Nees) Kunth — Tab. XVIb

DESCRIPTION: Perennial sedge with a long, scaly rhizome; culms decumbent at first then erect, to 50 cm. tall, fairly thick, trigonous, leafy for ⅔ of their length or more. Leaves numerous, 8 - 15 cm. long by 4 - 7 mm. wide. Inflorescence a simple or rarely subcompound umbel; bracts 3 - 5, somewhat longer than the umbel as a rule; umbel branches 4 - 10, 3 - 5 cm. long. Spikes with 3 - 8 spikelets, more or less crowded. Spikelets 12 - 16 - flowered, ovate-lanceolate, 5 - 12 mm. long by 3 - 4 mm. wide. Glumes brown in 2 opposite rows, 2.5 mm. long, broadly ovate, obtuse, not mucronate, closely packed. Stamens 3; nutlet brown, obovoid, about ⅓ the length of the glume; style branches 2.

DISTRIBUTION AND IMPORTANCE: Widespread in Africa and Madagascar. Also in Reunion, the Mediterranean region, the Middle East and Cuba. A swamp plant which is a troublesome weed in ricefields in Madagascar. Has also been noted as a constituent of sudd in Lukamba Swamp (Northern Rhodesia) and in Lake Tanganyika.

CONTROL: No literature available.

40. **Pycreus tremulus** (Poir.) C.B. CL. — **Cyperaceae**

Cyperus tremulus Poir. — Tab. XVIc
Pycreus albomarginatus Nees

DESCRIPTION: Annual sedge to 1 m. tall; stem triquetrous at the top. Leaves all basal, 3 - 6 mm. wide, grass-like. Inflorescence a compound umbel, with 4 - 8 bracts at its base similar in form to the leaves, varying in length and the longest sometimes attaining 40 cm. long. Main umbel branches 6 - 10, up to 20 cm. long. Spikelets in clusters of 4 - 6 lax spikes 2 - 3 cm. long, narrowly lanceolate, 5 - 20 mm. long by 2 - 2.5 mm. wide; glumes in 2 opposite rows, 2 mm. long, laxly imbricate, obovate, obtusely emarginate, not mucronate, brown with a hyaline, scarious margin; stamens 2. Nutlet brown, asymmetrically oblong, ¾ the length of the glume; style branches 2.

DISTRIBUTION AND IMPORTANCE: Widespread in tropical Africa and Madagascar. Also in Mauritius and Reunion. A troublesome ricefield weed in Madagascar.

CONTROL: Has been controlled in Madagascar by 1.5 kg./hectare 2, 4-D (ester) applied to the rice 5 weeks after sowing.

41. **Scirpus juncoides** Roxb. **Cyperaceae**

Hazondrano (Madagascar) Tab. XVId

DESCRIPTION: A perennial sedge with a short rhizome; culms up to 60 cm. tall, cylindric or subtriangular. Leaves reduced to sheaths with no lamina. Inflorescence of 2 - 5 spikelets in a single lateral head; lowest bract like a continuation of the stem, 3 - 10 cm. long; spikelets ovoid, subacute, 8 - 12 mm. long by 5 - 6 mm. wide. Glumes, straw coloured, very broadly ovate, 3.5 mm. long, very shortly mucronate, incurved; hypogynous bristles 5 - 6, equalling the nutlet. Stamens 3. Nutlet broadly obovoid, biconvex, apiculate, ⅔ the length of the glume, brown or black, very faintly horizontally punctate; style branches 2.

DISTRIBUTION AND IMPORTANCE: Widely distributed in Asia. Also in Reunion and Madagascar. A plant of swamps and wet places. A troublesome ricefield weed in Madagascar.

CONTROL: Careful preparation of the soil will help. 1 per cent. 2, 4-D (amine or ester derivatives) has been successfully employed in the Philippines.

42. Eleocharis dulcis (Burm. f.) Trin. **Cyperaceae**
Eleocharis plantaginea (Retz.) Roem. and Schult. Tab. XVIIa
Harefo (Madagascar)

DESCRIPTION: A stoloniferous, leafless sedge with a fairly thick rhizome; culms tufted, up to 8 cm. tall, cylindric, transversely septate. Inflorescence a single dense spikelet at the apex of the stems, straw coloured, tapering to the apex, 25 - 50 mm. long by 4 - 7 mm. wide. Glumes arranged spirally, loosely imbricate, oblong or obovate, obtuse, 6 - 8 mm. long. Hypogynous bristles 6 - 7, retrorsely scabrous, more or less as long as the nutlet. Nutlet smooth, olive-brown, broadly obovoid or ellipsoid, $\frac{1}{2}$ - $\frac{2}{3}$ the length of the glume; style branches 2 or 3.

DISTRIBUTION AND IMPORTANCE: In Asia, Australia, Polynesia, Madagascar, Mauritius and the Seychelles. Recorded in Africa from Dahomey, Guinea, Ivory Coast, Mali, Mauretania, Niger, Senegal, Upper Volta, Sierra Leone, Belgian Congo, Angola and Rhodesia. Grows in pools and wet places; troublesome ricefield weed in Madagascar.

CONTROL: No literature available.

43. Leersia hexandra Sw. **Graminae**
Rice grass Tab. XVIIb

DESCRIPTION: Perennial grass with long, creeping rhizomes, rooting from the lower nodes; culms up to 60 cm. or more tall; nodes shortly and densely hairy. Leaf-lamina expanded or rolled, broadly linear, tapering to a fine point, up to 20 cm. long, rough to the touch; ligule short and membranous. Inflorescence an open or contracted panicle up to 15 cm. long. Spikelets imbricate on one side of the inflorescence branches, 3.5 - 5 mm. long, awnless, shortly pedicelled, purple or pale- or yellow-green, falling soon after maturity. Glumes reduced; lemma glume-like, more or less oblong, scabrid on the keel and margins.

DISTRIBUTION AND IMPORTANCE: Throughout the tropics and subtropics. Widespread in Africa and Madagascar. Always grows in or near water. Recorded as a troublesome weed in rice in Madagascar.

CONTROL: No literature available.

44. Mimosa pigra L. **Mimosaceae**
Mimosa asperata L. Tab. XVIIc

DESCRIPTION: Erect or somewhat rambling shrub from 0.6 - 3 m. tall; stems with prickles up to 7 mm. long, appressed-setose. Leaves sensitive, bipinnate; petiole 0.3 - 1.5 cm. long; rhachis 3.5 - 12 cm. long with a prickle at the base of each of the 6 - 14 pairs of pinnae and often other prickles between; pinnae with 20 - 42 pairs of linear-oblong leaflets 3 - 8 mm. long, margins often setulose. Flowers mauve or pink in subglobose pedunculate heads c.1 cm. in diameter 1 - 2 together in the upper axils, mimosa or acacia-like. Pods clustered, brown, densely bristly, more or less flattened, 3 - 8 cm. long by 0.9 - 1.4 cm. wide, breaking up transversely into sections.

DISTRIBUTION AND IMPORTANCE: Widespread in tropical America and tropical Africa (including the Northern Transvaal); also in Madagascar and Mauritius. Introduced into Asia. A swamp plant of river and lake shores. Troublesome in ricefields in Madagascar.

CONTROL: Some success has been achieved with applications of 2, 4-D, 2, 4, 5-T mixtures. Spraying with 1.5 per cent. sodium arsenite is also reported to give a kill.

45. Neptunia oleracea Lour. **Mimosaceae**
N. prostrata Baill. Tab. XVIId

DESCRIPTION: Aquatic or subaquatic herb with thick prostrate stems rooting at the nodes. Leaves sensitive, bipinnate with 2 - 3 pairs of opposite pinnae; leaflets in 8 or more pairs, linear-oblong, rounded at the apex, glabrous, up to about 1.5 cm. long; often with finely dissected, submerged leaves also. Flowers yellow, capitate, on elongated, erect, stout peduncles up to 20 cm. long, upper flowers bisexual, lower neuter. Florets like those of an *Acacia* or *Mimosa* but lower neuter florets with much elongated petals and staminodes. Pod flattened, oblong, shortly stalked, sharply beaked, glabrous, c.2.5 cm. long.

DISTRIBUTION AND IMPORTANCE: Widespread in tropical Africa and Madagascar. It occurs in Zululand (Natal) and is also widespread in tropical Asia and America. This species is recorded as troublesome in West Tropical Africa but may be potentially harmful throughout most of tropical Africa.

CONTROL: No information beyond the use of manual methods.

46. **Bacopa erecta** Hutch. and Dalz. **Scrophulariaceae**

Tab. XVIIIa

DESCRIPTION: Erect herb with spongy stems up to 0.6 m. tall; stem quadrangular, often branching, glabrous or glandular. Leaves opposite, sessile, up to c.6 cm. long by 2 cm. wide, more or less acute at the apex, narrowed and often more or less eared at the base, minutely serrate in the upper half, densely glandular-punctate below. Flowers small, white, solitary in the axils, but often crowded towards the ends of the branches; peduncles up to c.7 mm. long; bracts shorter than the peduncles and more or less linear. Upper (posticous) calyx segment enlarged, c.1 cm. long, oblong-elliptic, entire or toothed, glandular. Corolla c.1 cm. long, slightly 2-lipped. Capsule ovoid, c.6 mm. long, glandular, 2-locular, seeds many.

DISTRIBUTION AND IMPORTANCE: A Mexican species probably introduced in Africa. Well known as a swamp plant and as a ricefield weed in Sierra Leone and the Gambia. Also in Guinea and Senegal.

CONTROL: No literature available.

47. **Sphenoclea zeylanica** Gaertn. **Campanulaceae**

Tab. XVIIIb

DESCRIPTION: An erect, glabrous, annual herb up to 1.3 m. tall; stem stout, subfleshy, branching as a rule. Leaves alternate, linear-lanceolate to lanceolate, apex acute, base cuneate, margin entire, 2.5 - 16 cm. long; petiole slender, c.5 mm. long. Flowers greenish- or mauve-tinged, regular, 4 - 5 mm. in diameter, in dense spikes up to 7.5 cm. long. Calyx 5-lobed. Corolla campanulate, 3-lobed. Stamens 3, alternating with the corolla lobes and free or attached at the corolla base, filaments dilated at the base. Ovary 2-locular, ovules numerous; style short; stigma shortly 2-fid. Capsule depressed-globose, opening transversely. Seeds numerous, very small.

DISTRIBUTION AND IMPORTANCE: Widely distributed in Africa from the Transvaal northwards. Also in tropical Asia and America. A marsh plant troublesome in rice-fields in Madagascar. Also recorded as a weed of rice in Louisiana.

CONTROL: Can be killed when young by 2, 4-D. In the Philippines 2, 4, 5-T is recommended.

III. PLANTS DANGEROUS IN OTHER PARTS OF THE WORLD (NOT KNOWN IN AFRICA OR MADAGASCAR SO FAR)

48. **Elodea canadensis** Michx. **Hydrocharitaceae**

Anacharis canadensis (Michx.) Planch. Tab. XVIIIc
Canadian waterweed.

DESCRIPTION: Submerged aquatic herb; stems tender, branching, very brittle, up to 3 m. long. Leaves sessile, in whorls of 3 or rarely 4, lower leaves sometimes opposite, lanceolate- or linear-oblong, c.10 mm. long by 3 - 4 mm. wide, translucent, minutely serrate, with minute entire scales on the upper side of the leaf towards the base. Flowers dioecious, solitary, their bases enclosed in sessile, narrow spathes in the axils of the upper leaves; perianth of female flower greenish purple, of 3 sepals and 3 petals, to c.5 mm. in diameter, with a very fine gynoecium up to 30 cm. long but usually less; male flower with a long, fine pedicel and 3 - 6 stamens.

DISTRIBUTION AND IMPORTANCE: A North American species introduced into Europe during the nineteenth century. It blocked many waterways after its original rapid spread but has more recently diminished in importance. Could no doubt be a serious threat, at least in the more temperate regions of Africa. It has been recorded only as an aquarium plant in Natal and there is a record of the introduction of a related South American species *Egeria densa* Planch. *(Elodea densa* (Planch.) Casp.) to Northern Kenya. *Elodea canadensis* is a rice-field weed in Portugal.

CONTROL: *Elodea canadensis* has been controlled by:—

(1) 400 - 500 lb./acre copper sulphate.
(2) 5 p.p.m. sodium arsenite.
(3) 1 p.p.m. kuron.
(4) 10 galls./cu. ft./sec. of flow applied for 30 minutes of chlorinated benzene (in irrigation furrows).

In rice it can be controlled by drying out the fields.

49. Alternanthera philoxeroides (Mart.) Griseb. **Amaranthaceae**
Alligator weed Tab. XVIIId

DESCRIPTION: Perennial herb with stems at first prostrate then erect to 0.5 cm. tall, rooting at the lower nodes, hairy in 2 lines down the striate stem and in the leaf-axils. Leaves shortly petiolate, 3.5 - 11 cm. long, thin, oblong-lanceolate, acute or obtuse at the apex, cuneate at the base, margin entire or slightly denticulate. Flowers in long, pedunculate, axillary heads; heads solitary, subglobose, c.1 cm. in diameter, white and shining; bracts 3, ⅓ the length of the tepals. Tepals 5, oblong-lanceolate, acuminate, mucronate, 4 - 6 mm. long. Stamens 5; staminodes longer than the stamens. Ovary subglobose; 1-ovulate. Seed reddish brown, shining.

DISTRIBUTION AND IMPORTANCE: Indigenous in tropical and subtropical America. Introduced in Java. An important weed in America often associated with *Eichhornia crassipes*. When *Eichhornia crassipes* is brought under control it is often replaced by *Alternanthera philoxeriodes*.

CONTROL: When growing on land the stems can be killed with 2, 4-D but not when growing in water. Underwater applications of diuron and the dimethylamine salts of 2, 4-D and MCPA show promise when the plant is growing in water.

50. Hydrocleys nymphoides (Willd.) Buchen. **Butomaceae**
Tab. XIXa

DESCRIPTION: Glabrous, aquatic herb rooting in mud; stems elongate, rooting at the nodes. Leaves clustered; lamina broadly ovate to suborbicular, up to 5.5 cm. long by 2 - 4.5 cm. wide, obtuse at the apex, slightly cordate at the base, entire, rather thick, 7-nerved; midribs thickened, spongy with a pore at the apex; petiole 6 - 25 cm. long, transversely septate. Flowers solitary or a few together on a bracteate peduncle; bracts c.30 mm. long by 5 mm. wide. Sepals 3, free, lanceolate to narrowly ovate, 2 cm. long. Petals 3, yellow, with a darker base, free, broadly obovate to orbicular-cuneate, c.3 cm. long by 4 cm. wide. Stamens several with purplish anthers and filaments; staminodes several. Carpels 6, cohering at the base.

DISTRIBUTION AND IMPORTANCE: Indigenous in central and tropical South America. Often cultivated in hothouses in temperate regions. This could be a dangerous plant if introduced to Africa (there is in fact one record of its introduction in Nairobi but these plants have probably been removed). Four other species also occur in tropical South America.

CONTROL: No literature available.

51. **Sparganium** spp. **Sparganiaceae**
Bur reeds Tab. XIXb

DESCRIPTION: Rhizomatous aquatic herbs; stems simple and branched, leafy; leaves elongated, erect or floating, sheathing at the base. Flowers unisexual, wind pollinated, crowded in globose clusters along the upper part of the stem, the male above the female in each inflorescence. Perianth of a few membranous scales. Male flowers with 3 or more stamens. Female flower with a 1-locular sessile ovary; style simple or forked. Fruits indehiscent, crowded in globose heads, with spongy layer outside, hard within, 1-seeded.

DISTRIBUTION AND IMPORTANCE: About 15 species mainly in the temperate regions of the Northern Hemisphere but *S. erectum* L. and *S. fallax* Graebn. occur in India and *S. antipodum* Graebn. in Australia and New Zealand. We could not assume therefore that they would not thrive in Africa if introduced here. Several species occur as ricefield weeds in Portugal.

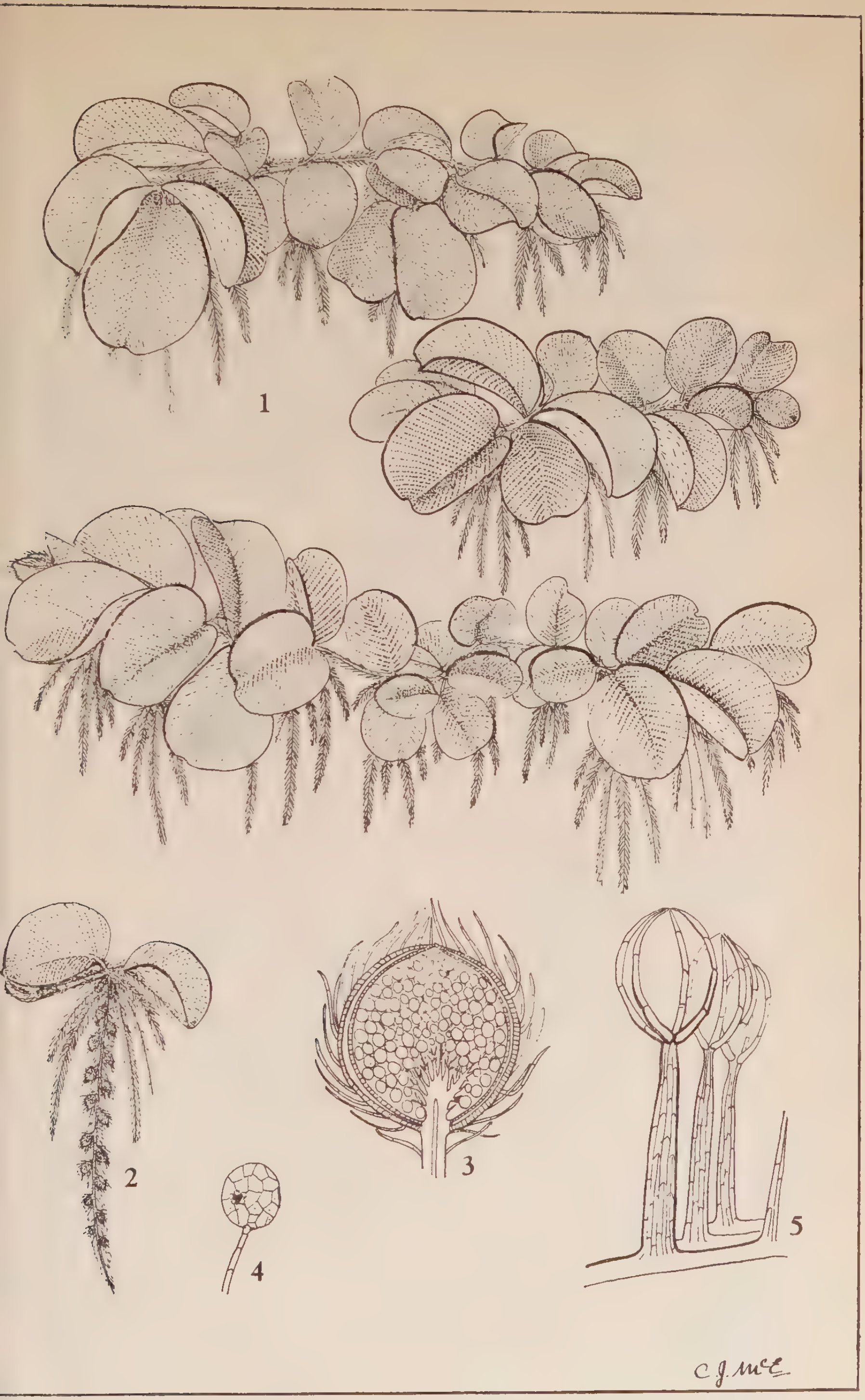
CONTROL: CMU has been used to control *Sparganium* spp. in the United States. 2, 4-D has been used with some success in Portugal with the European species and drying out the soil will help keep them under control. It is important to remove all rhizomes and destroy plants before they seed.

52. Nelumbo nucifera Gaertn. **Nymphaeaceae**
Nelumbium speciosum Willd. Tab. XIXc

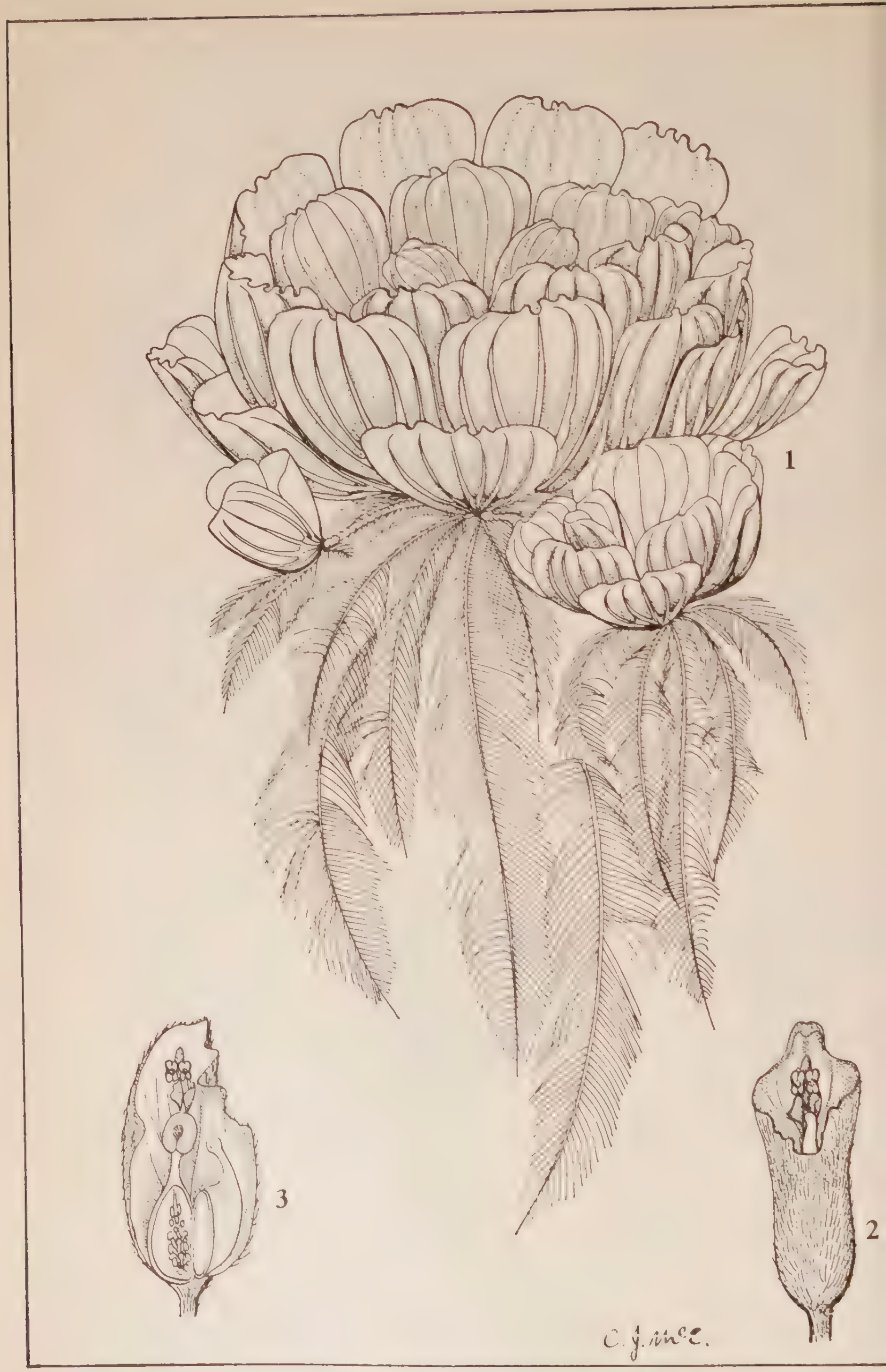
DESCRIPTION: An erect, aquatic perennial with a milky juice; rootstock large, creeping. Leaves raised on long petioles up to 2 m. tall above the water, peltate, up to 1 m. in diameter, membranous and cupped. Flowers up to 30 cm. in diameter on long peduncles. Sepals 4 - 5. Petals and stamens many in many rows; anthers with a clubbed appendage. Carpels, many, sunk in a large, spongy torus. Seed usually single and filling the carpel which when ripe is 1 - 2 cm. in diameter.

DISTRIBUTION AND IMPORTANCE: Throughout Persia, India, China, Africa and Japan. Also in tropical Australia. A very decorative plant not usually considered a weed but caution would need to be exercised if it were introduced to Africa.

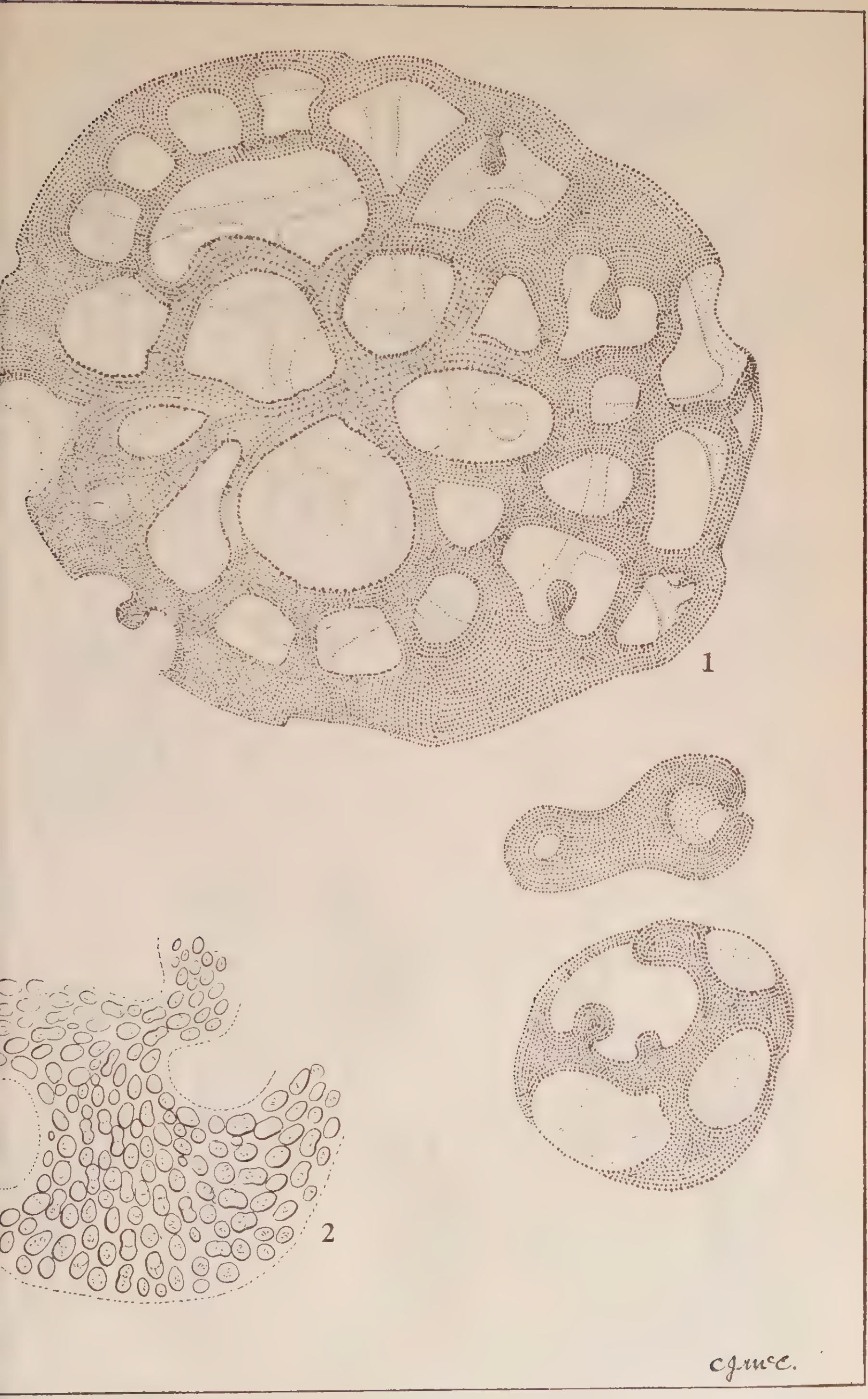
CONTROL: No literature available.



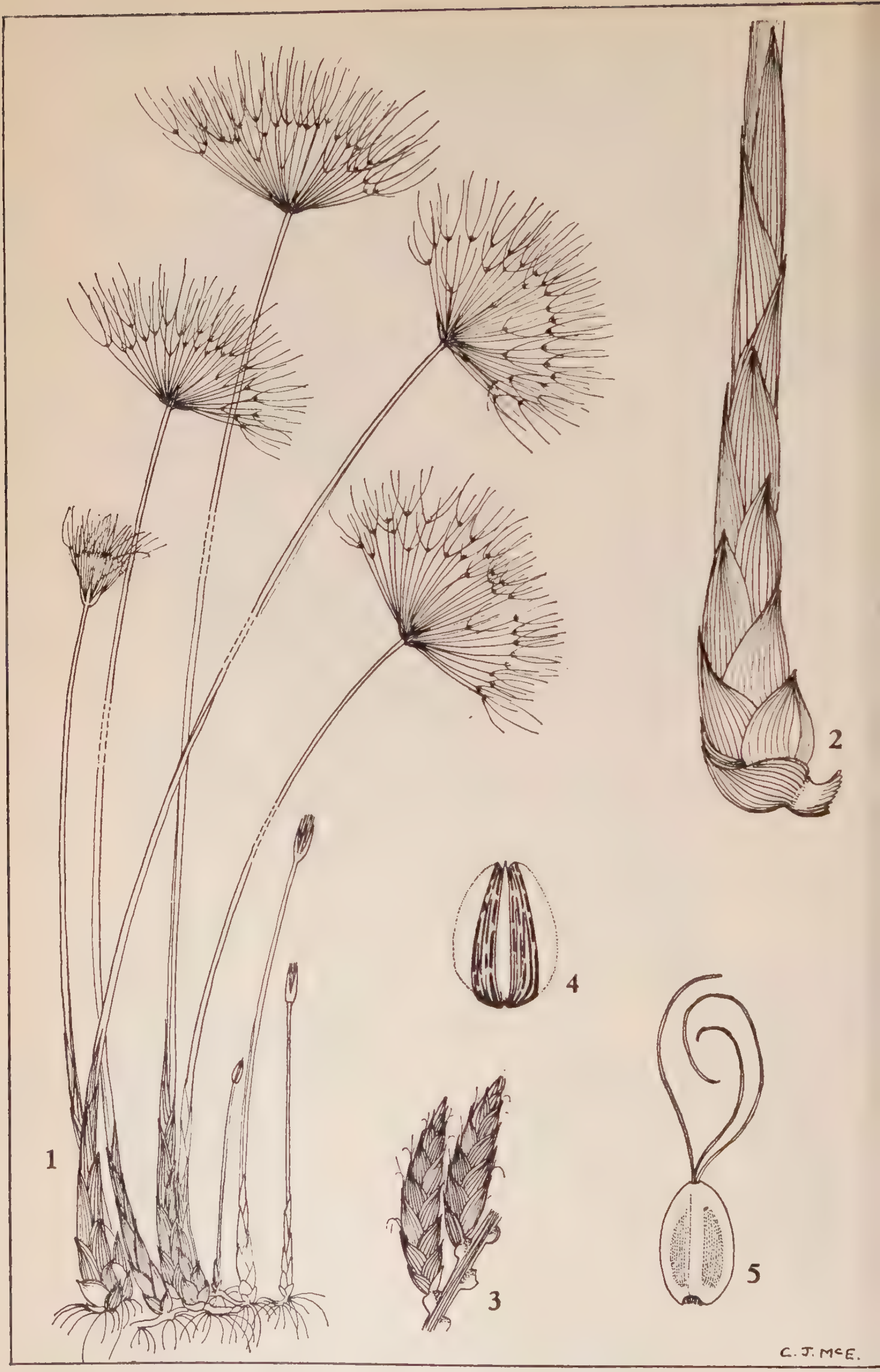
b. I.—**Salvinia auriculata.** 1, three whole plants (× ⅔). 2, portion of plant with sporocarps 3, sporocarp containing microsporangia (× 8). 4, microsporangium (× 12). 5, hair from surface of floating leaf (× 24).



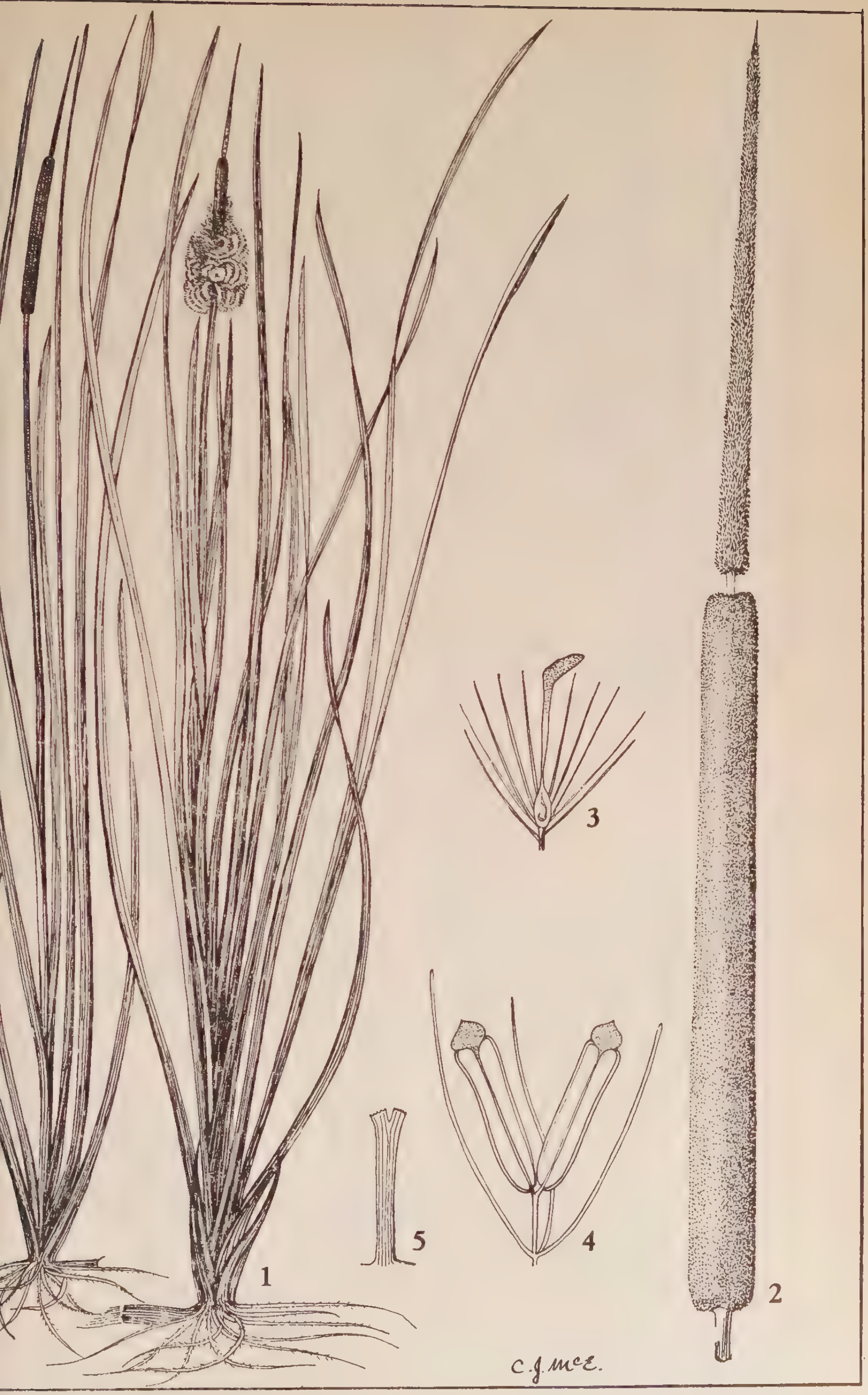
Tab. II. **Pistia stratiotes.** 1, whole plant reproducing vegetatively (× ⅔). 2, spathe (×
spathe split open to show spadix with male and female flowers (× 4).



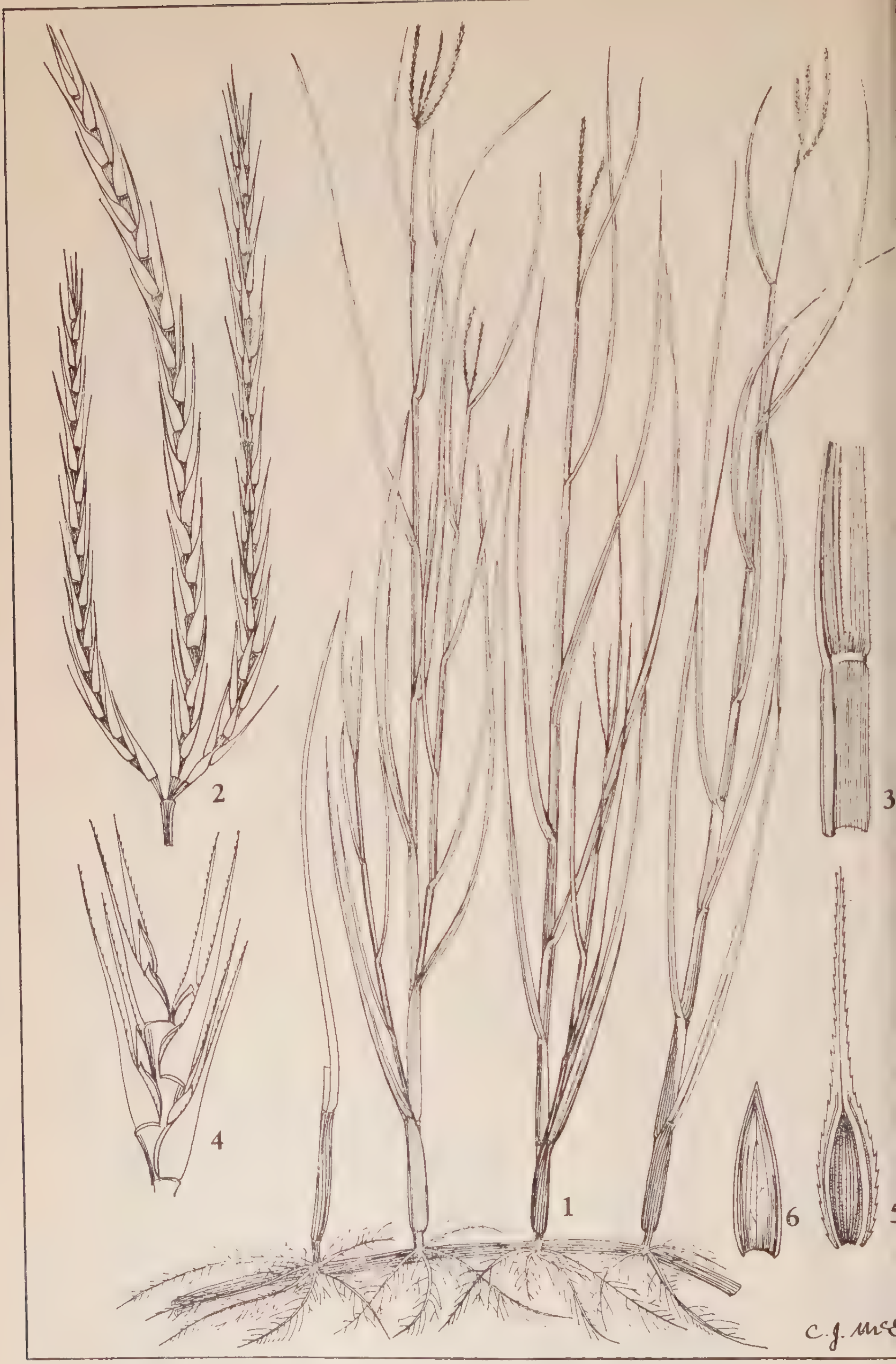
b. III. **Microcystis toxica.** 1, three colonies (× 50). 2, individual cells embedded in gelatinous (× 300).



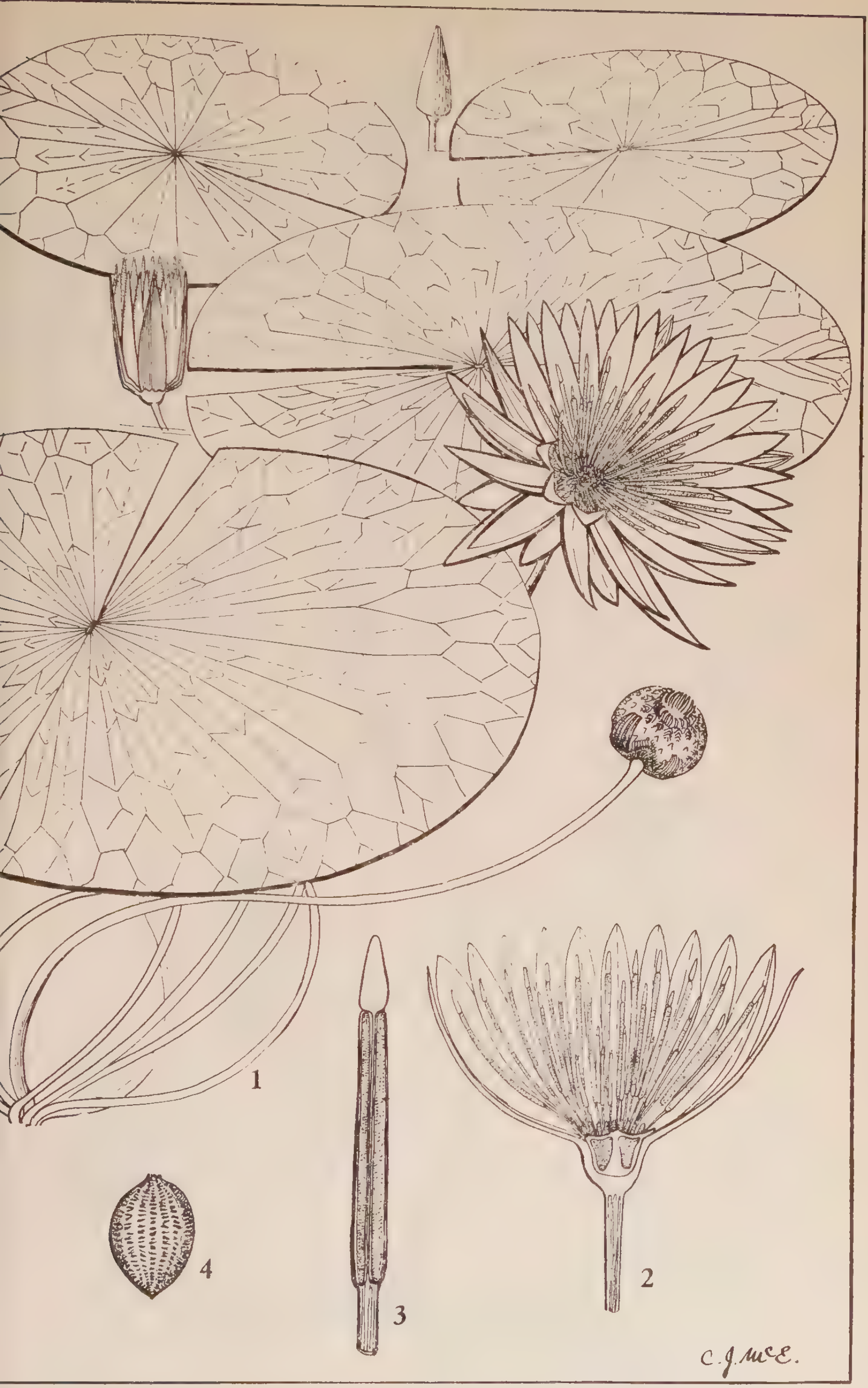
Tab. IV. **Cyperus papyrus.** 1, group of plants (× $\frac{1}{9}$). 2, base of stem (× $\frac{1}{3}$). 3, two spike
(× $\frac{8}{3}$). 4, glume (× 12). 5, nutlet (× 16).



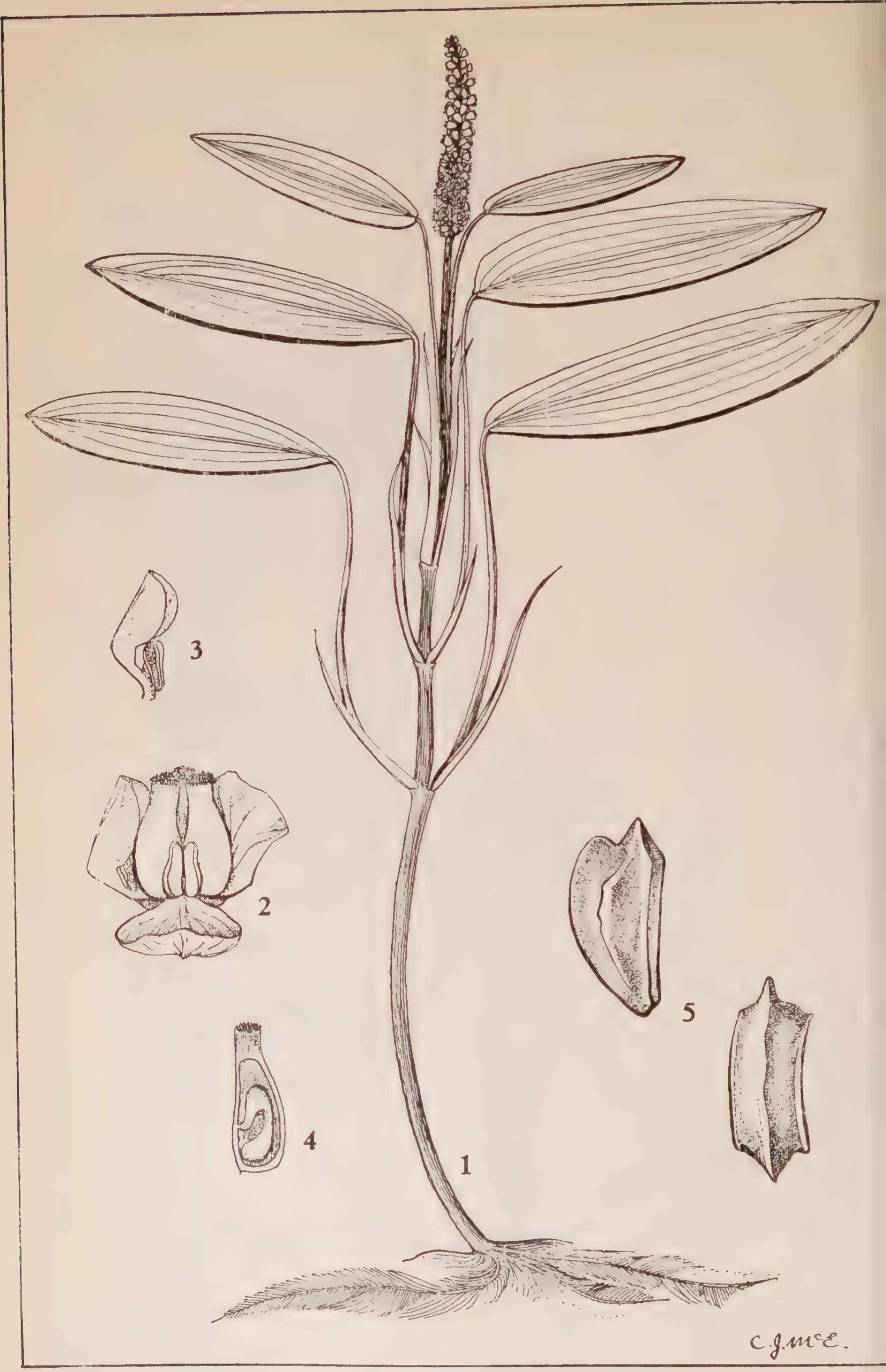
b. V. **Typha capensis.** 1, two plants (× $\frac{1}{15}$). 2, inflorescence (× $\frac{2}{3}$). 3, female flower (× 12). flower (× 8). 5, bracteole (× 24).



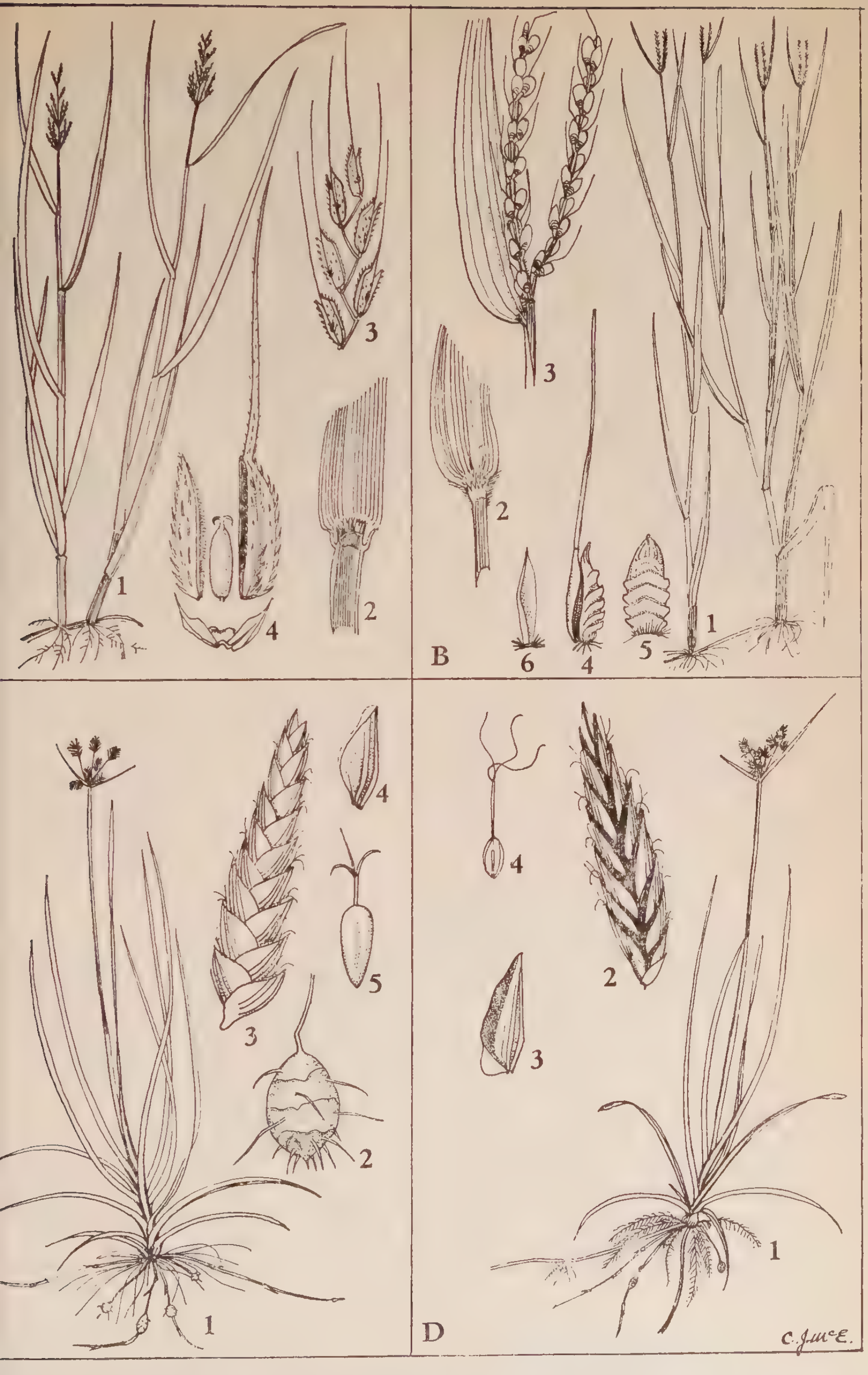
Tab. VI. **Vossia cuspidata.** 1, whole plant (× $\frac{1}{9}$). 2, inflorescence (× $\frac{2}{3}$). 3, ligule (× $\frac{2}{3}$). 4 tion of rhachis with spikelets (× $\frac{4}{3}$). 5, lower glume of sessile spikelet (× 2). 6, upper glu sessile spikelet (× 2).



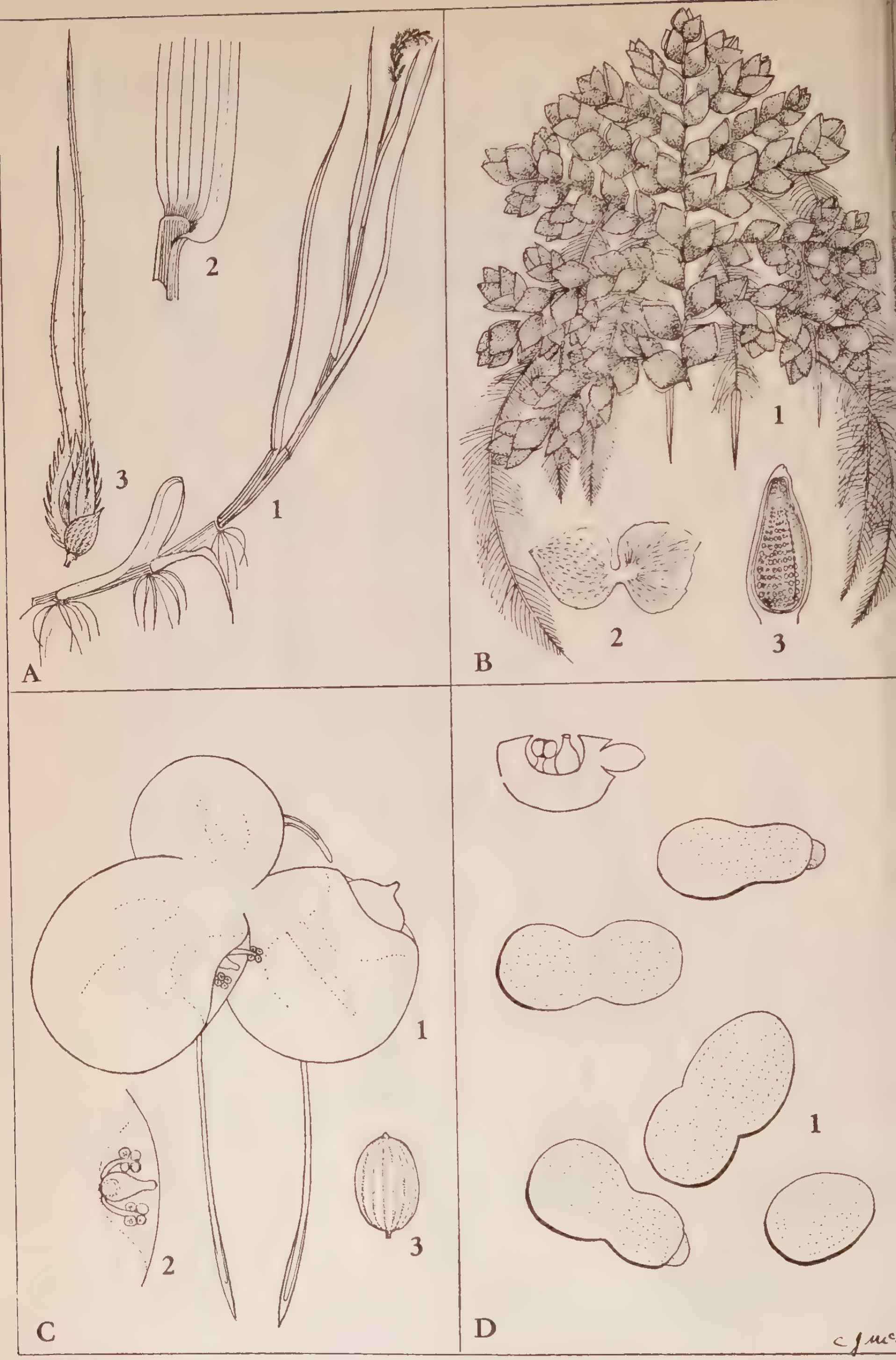
b. VII. **Nymphaea caerulea.** 1, plant ($\times \frac{2}{5}$). 2, longitudinal section of flower ($\times \frac{2}{5}$). 3, anther
4, seed ($\times$ 16).



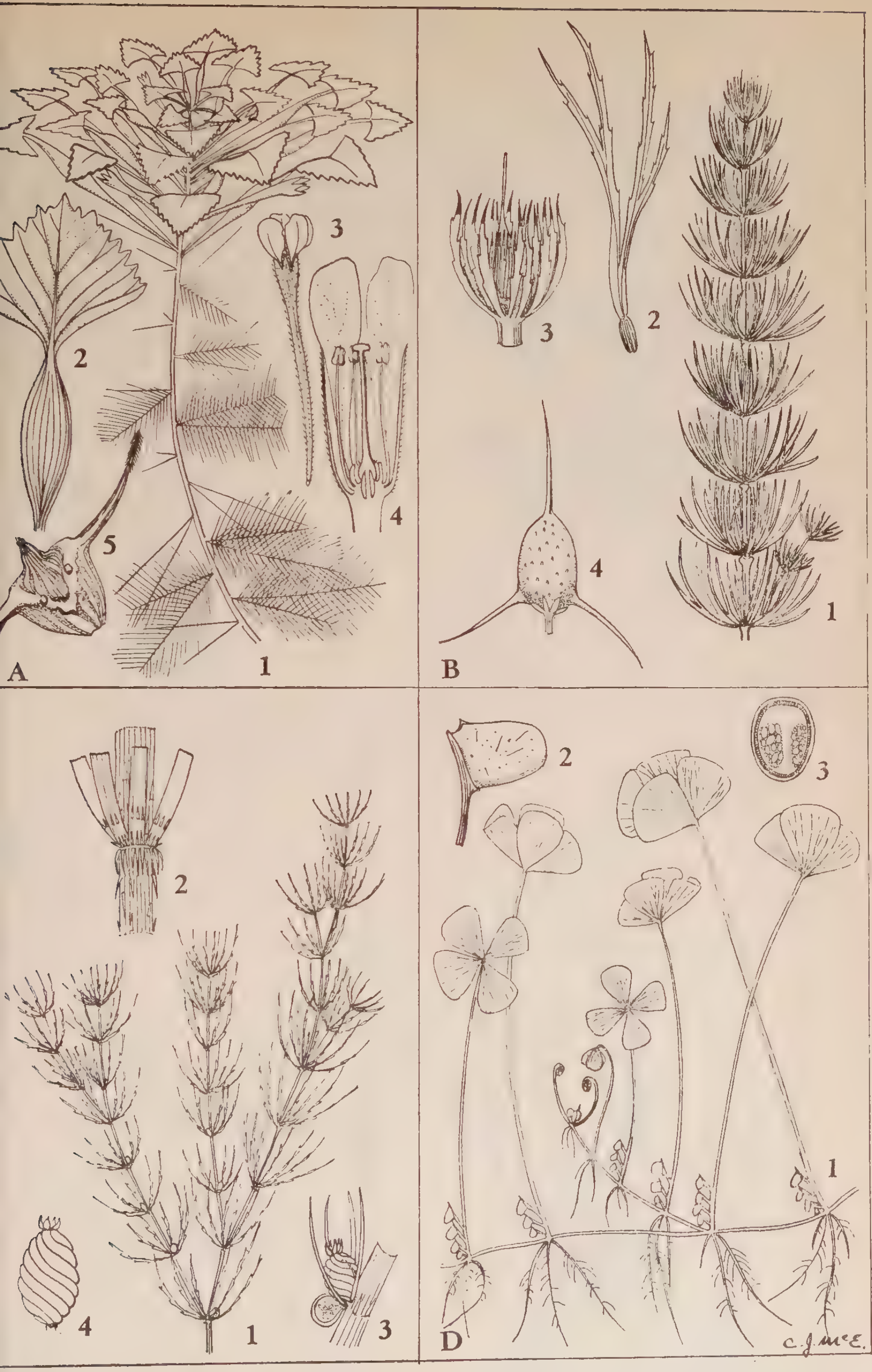
Tab. VIII. **Potamogeton richardii.** 1, whole plant (× ⅔). 2, flower (× 8). 3, perianth seg
with anther (× 8). 4, carpel dissected to show ovule (× 8). 5, seeds in side and dorsal view (×



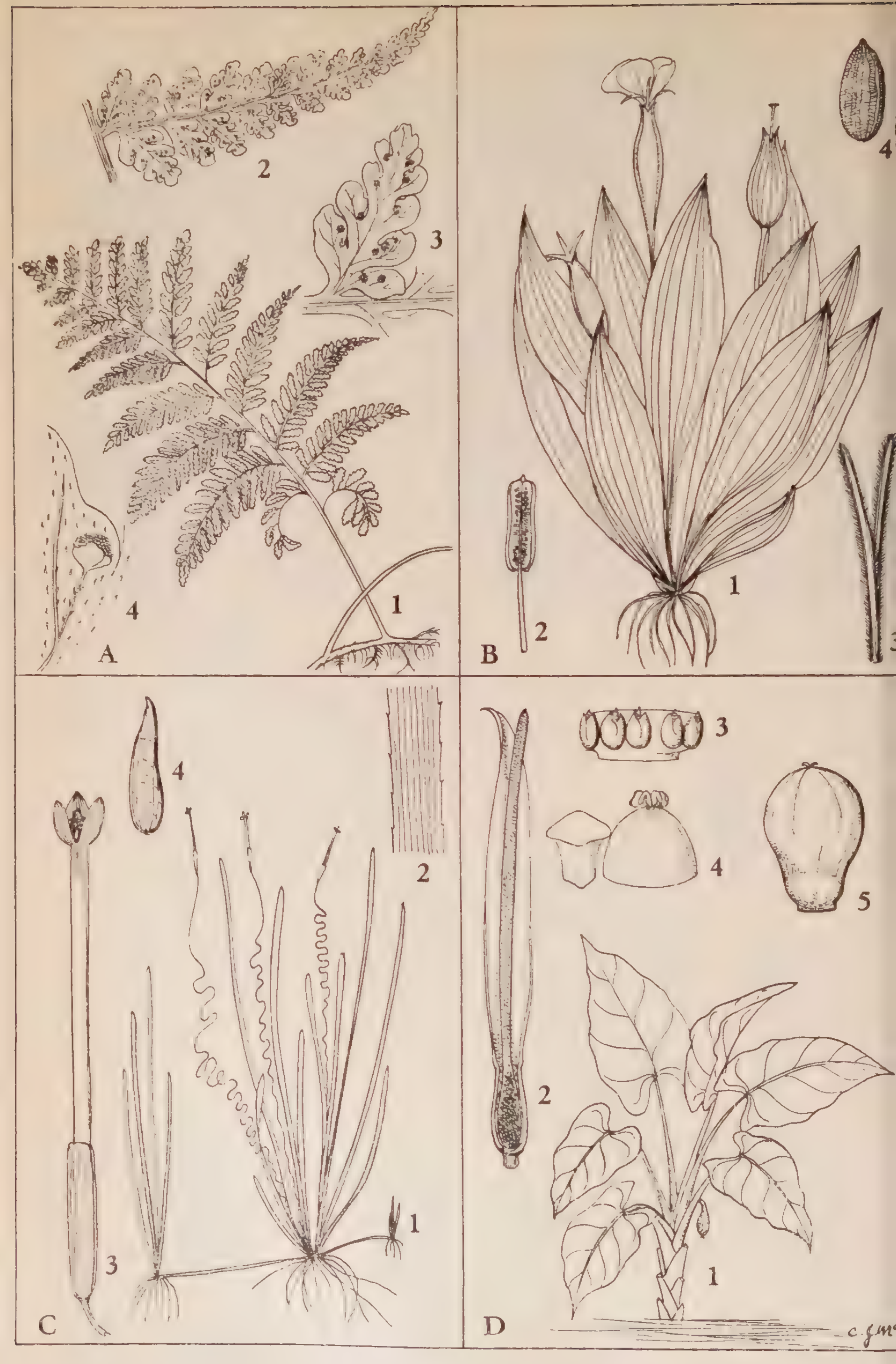
Tab. IX. A.—**Oryza perennis.** 1, whole plant (× $\frac{1}{18}$); 2, ligule (× $\frac{2}{3}$); 3, portion of inflorescence
); 4, dissected spikelet (× 2). B.—**Ischaemum rugosum.** 1, whole plant (× $\frac{1}{15}$); 2, ligule (× $\frac{2}{3}$);
lorescence (× $\frac{2}{3}$); 4, spikelet (× 2); 5, lower glume of sessile spikelet (× 2); 6, pedicelled spikelet
). C.—**Cyperus esculentus.** 1, whole plant (× $\frac{1}{15}$); 2, tuber (× $\frac{4}{3}$); 3, spikelet (× 4); 4, glume
); 5, nutlet (× 6). D.—**Cyperus rotundus.** 1, whole plant (× $\frac{1}{15}$); 2, spikelet (× 4); 3, glume
); 4, nutlet (× 4).



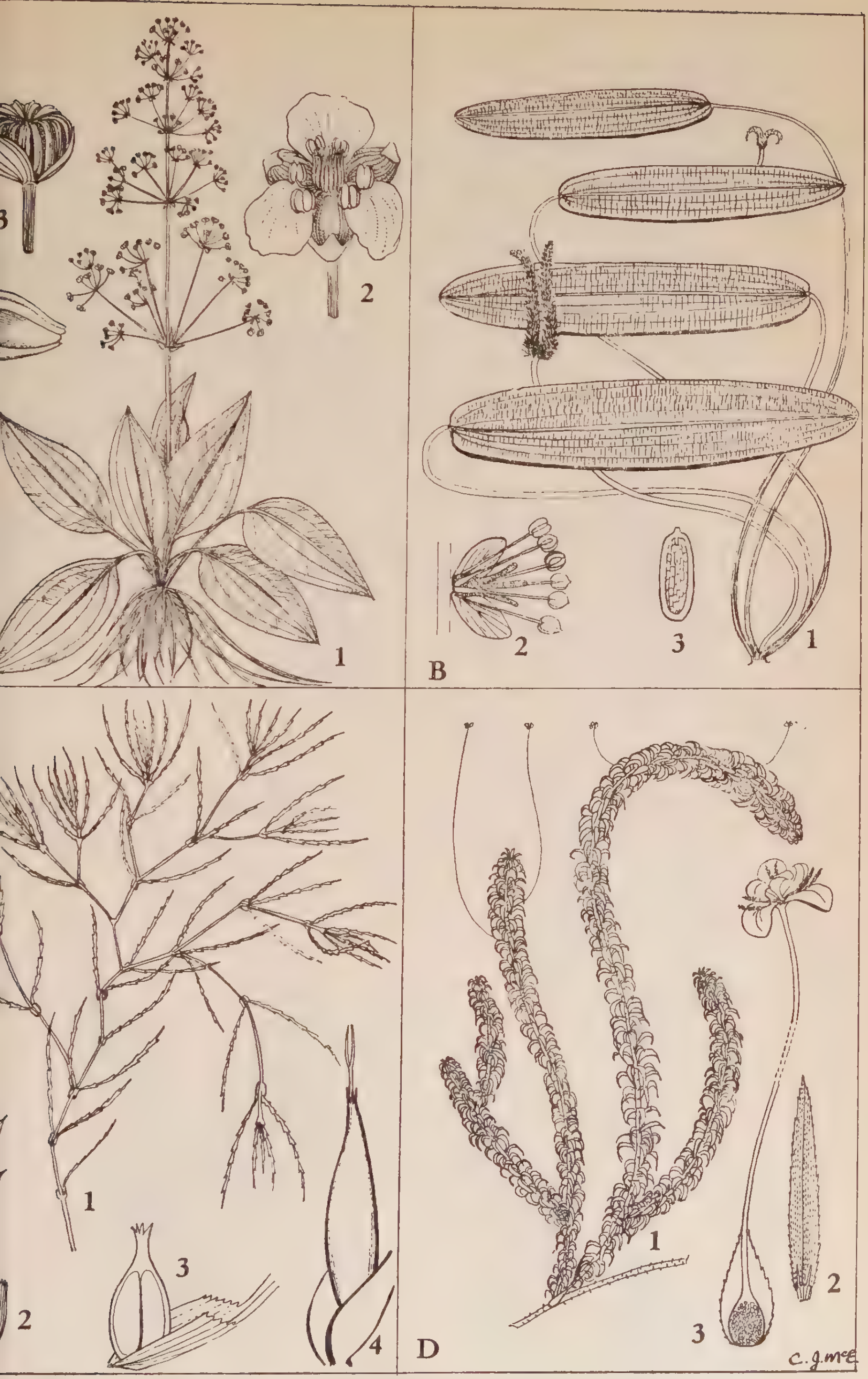
Tab. X. A.—**Echinochloa stagnina.** 1, whole plant (× $\frac{1}{15}$); 2, ligule (× $\frac{4}{3}$); 3, spikelet (×
B.—**Azolla africana.** 1, whole plant (× 6); 2, leaf with two lobes (× 10); 3, sporocarp with par
wall removed to show microsporangia (× 20). C.—**Lemna aequinoctialis.** 1, whole plant (×
2, inflorescence (× 40); 3, seed (× 25). D.—**Wolffa arrhiza.** 1, five individual plants (× 40); 2, lo
tudinal section of plant showing inflorescence, after Hegelmaier, Monographie der Lemnaceen, 1
(× 40).



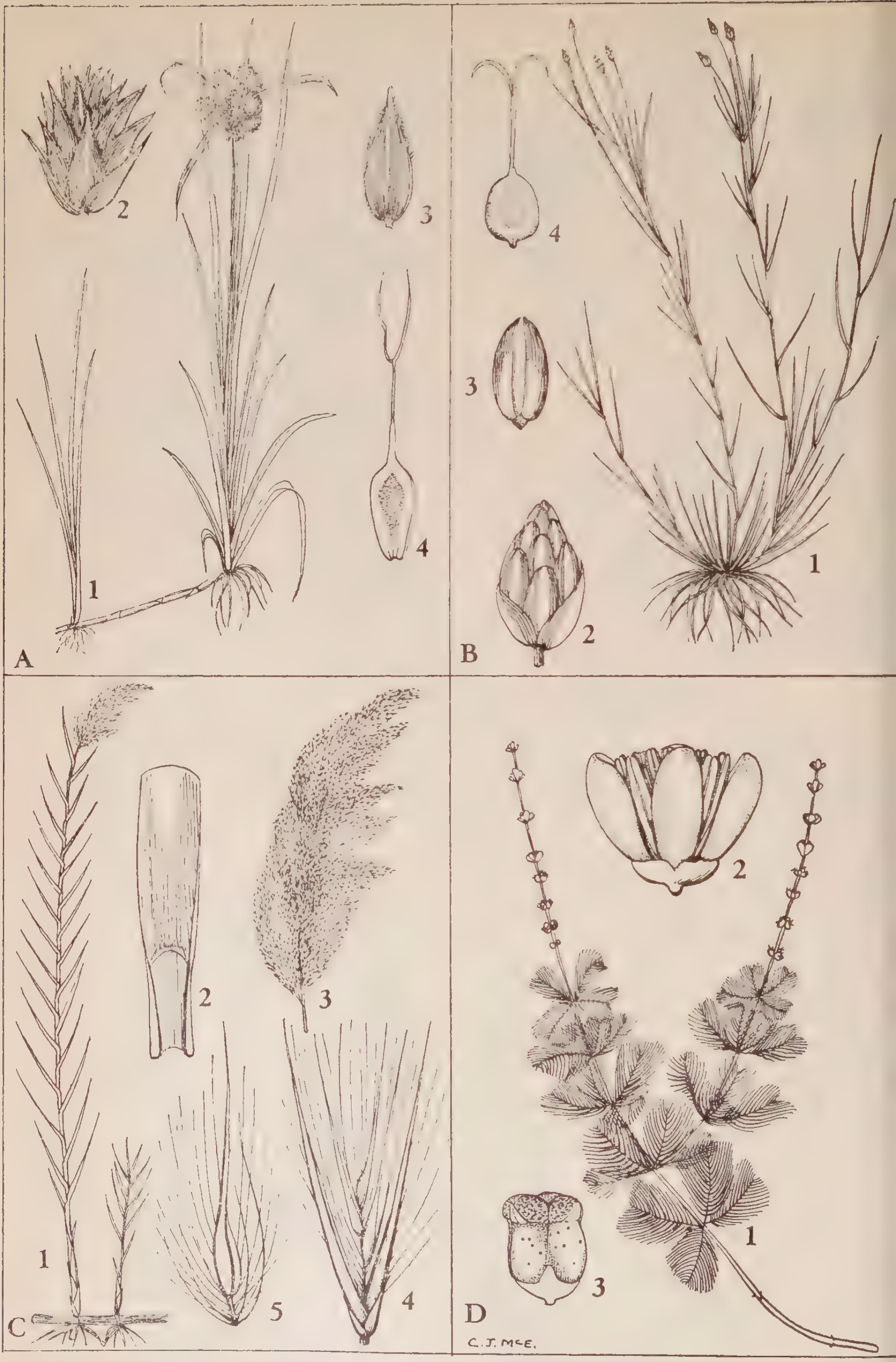
Tab. XI. A.—**Trapa natans.** 1, whole plant ($\times \frac{1}{6}$); 2, leaf ($\times \frac{2}{3}$); 3, flower ($\times \frac{2}{3}$). 4, longitudinal
on of flower ($\times$ 3); 5, fruit ($\times \frac{2}{3}$). B.—**Ceratophyllum demersum.** 1, stem with leaves ($\times \frac{2}{3}$);
af ($\times$ 2); 3, female flower ($\times$ 6); 4, fruit ($\times$ 6). C.—**Chara pseudobrachypus.** 1, portion of plant
); 2, node with secondary branches and spine-cells ($\times$ 15); 3, oogonium and antheridium ($\times$ 15);
spore ($\times$ 30). D.—**Marsilea rotundata.** 1, whole plant ($\times \frac{2}{3}$); 2, sporocarp ($\times$ 2); 3, vertical
on of sporocarp to show the sori embedded in the gelatinous contents ($\times$ 2).



Tab. XII. A.—**Microlepia speluncae.** 1, frond (× $\frac{1}{20}$); 2, small pinna (× $\frac{2}{3}$); 3 pinnule (×
4, indusium with sori (× 10). B.—**Ottelia ulvifolia.** 1, whole plant (× $\frac{1}{3}$); 2, stamen (× 4); 3, st
(× 4); 4, seed (× 8). C.—**Vallisneria aethiopica.** 1. whole plant (× $\frac{1}{3}$); 2, portion of leaf (× 2)
female flower (× 6); 4, seed (× 6). D.—**Typhonodorum lindleyanum** (after Engler, Pflanzenw
Afrikas 2, figs. 169 and 170 (1908). 1, whole plant (× $\frac{1}{40}$); 2. spathe (× $\frac{1}{15}$); 3, male flowers (×
4, gynoecium and staminode (× $\frac{8}{3}$); 5, fruit (× $\frac{2}{3}$).



b. XIII. A.—**Alisma plantago-aquatica.** 1, whole plant (× $\frac{1}{20}$); 2, flower (× 4); 3, fruit (× 4); ing carpel (× 6). B.—**Aponogeton desertorum.** 1, whole plant (× $\frac{1}{3}$); 2, flower (× 6); 3, seed C.—**Najas interrupta.** 1, portion of plant (× $\frac{2}{3}$); 2, leaf-base with auricles (× 8); 3, male (× 8); 4, female flower (× 8). D.—**Lagarosiphon major.** 1, portion of plant (× $\frac{1}{5}$); 2, leaf 3, female flower (× 10).



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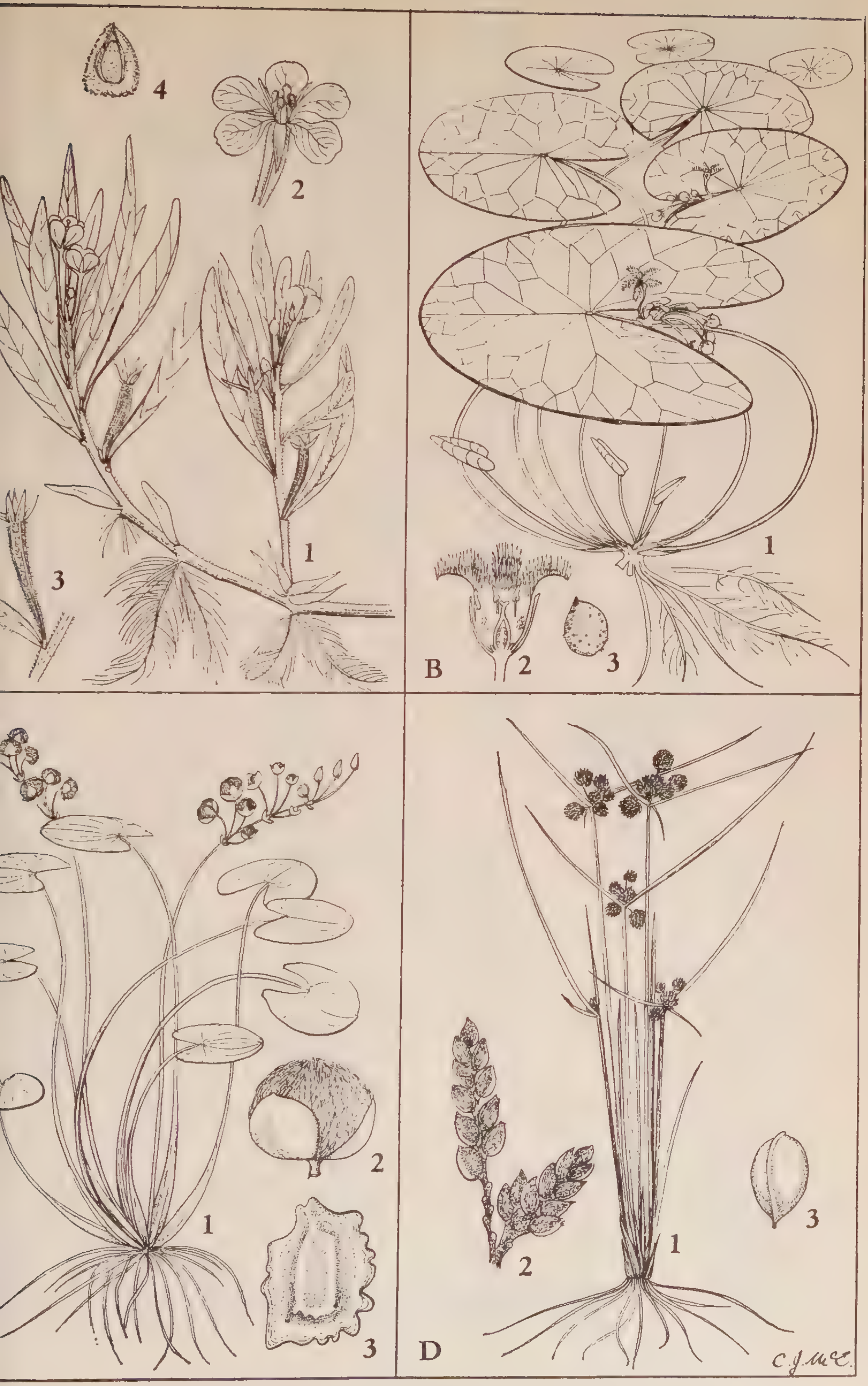

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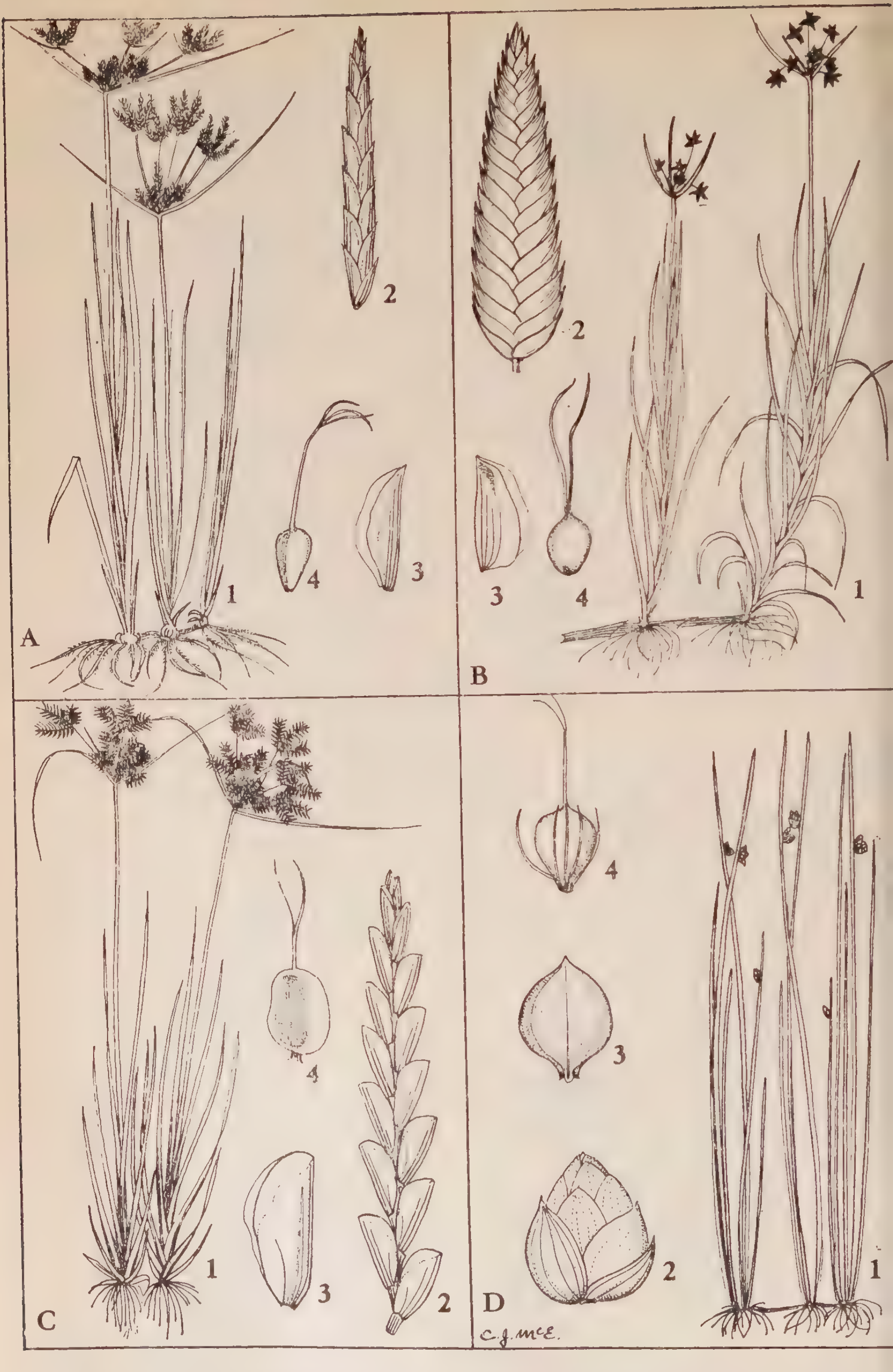

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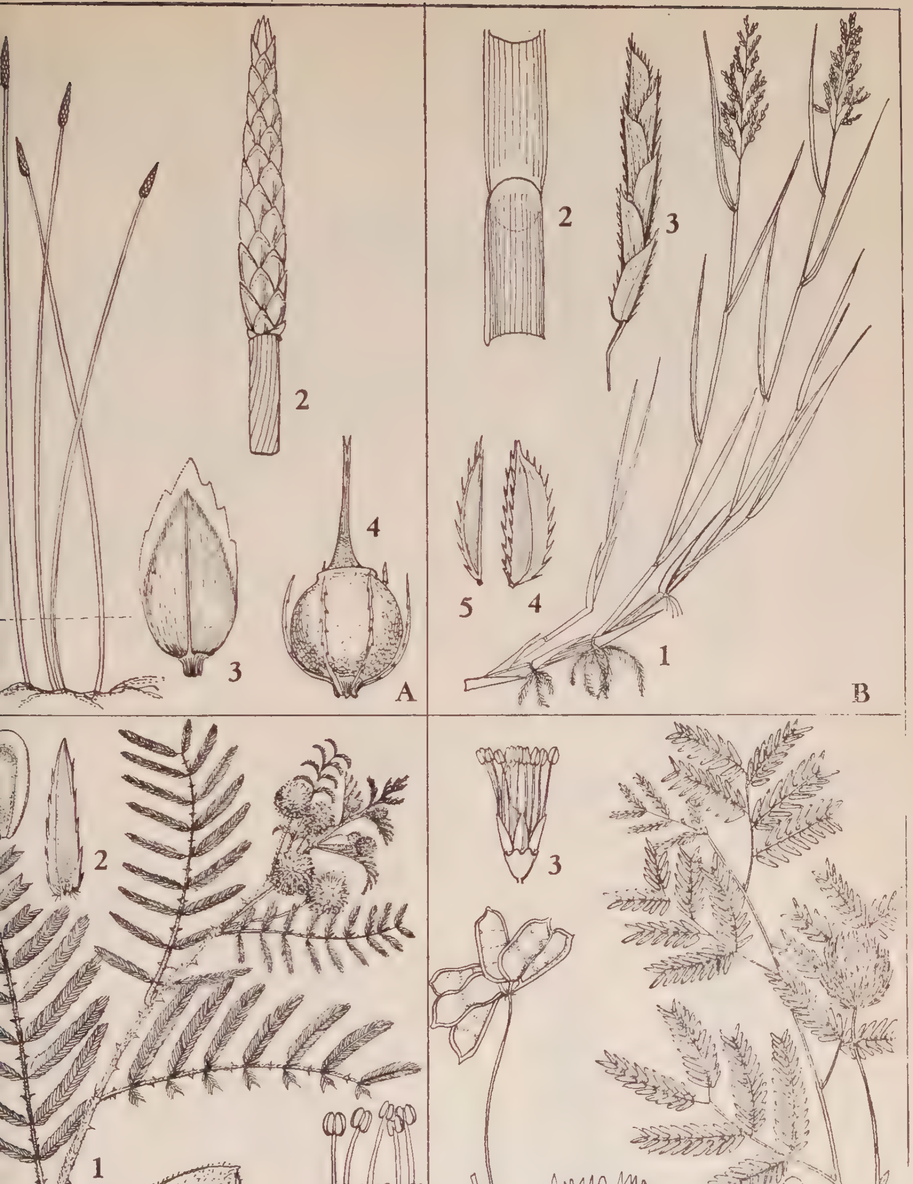

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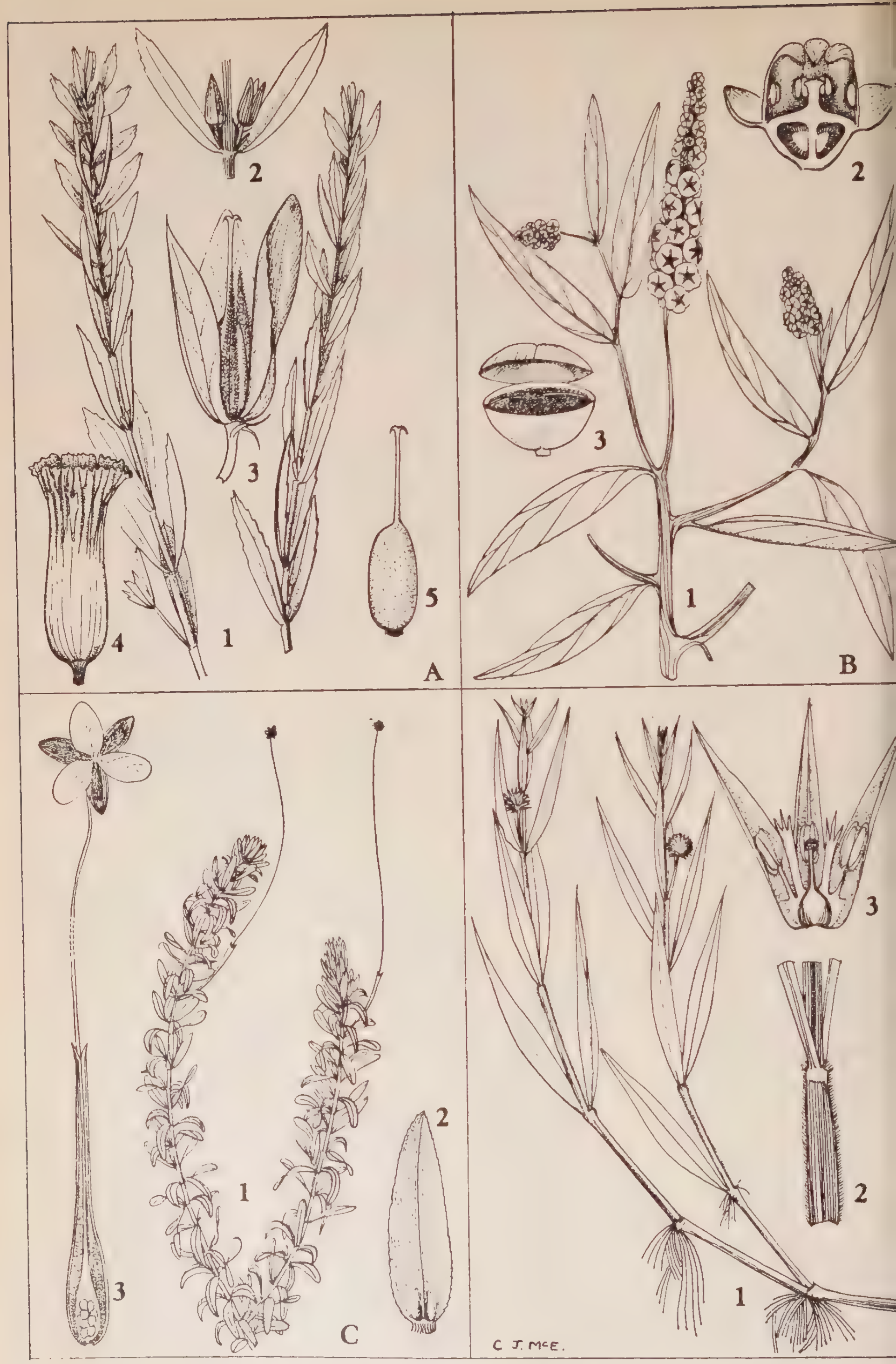

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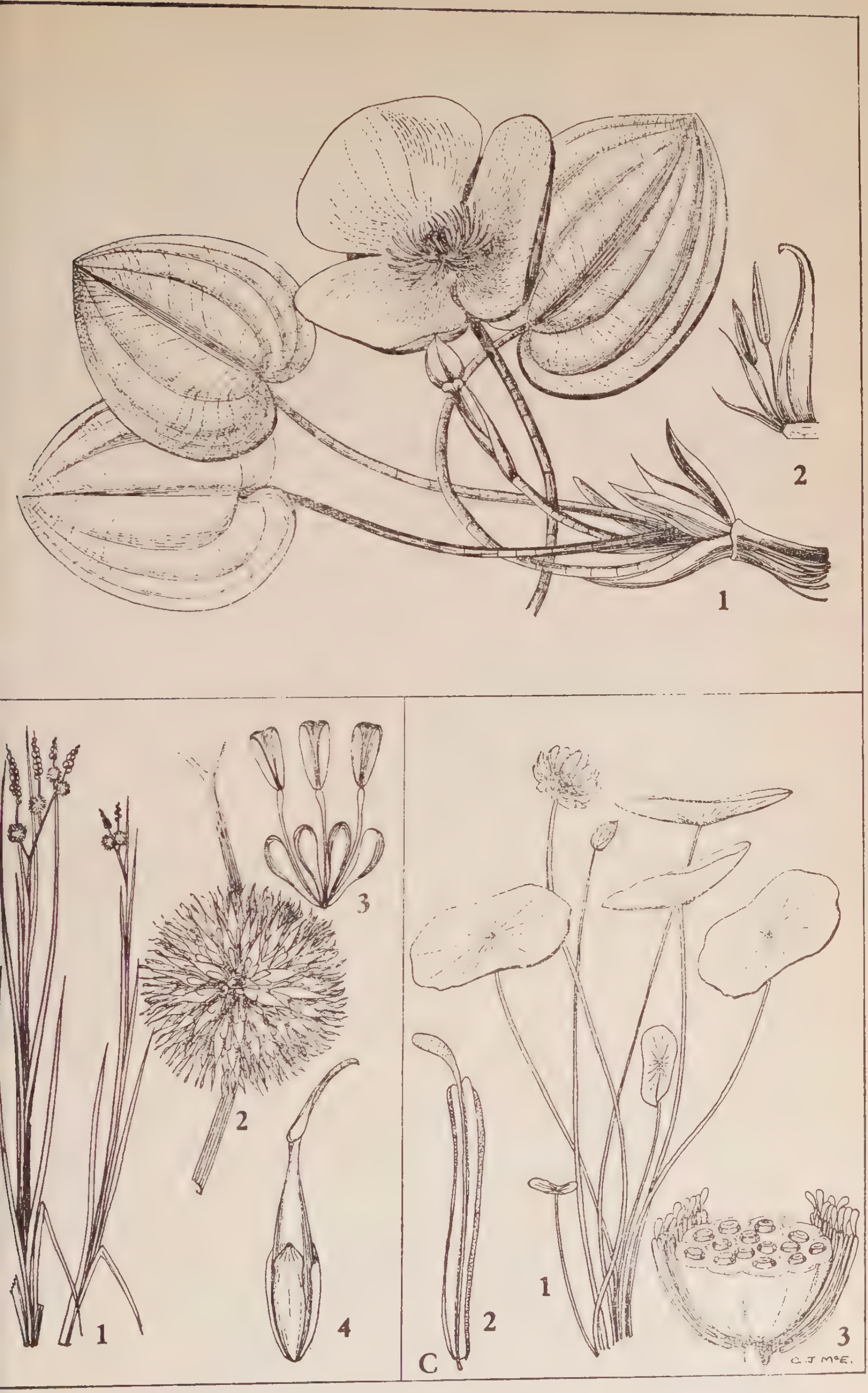

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GLOSSARY OF BOTANICAL TERMS

actinomorphic (regular), applied to flowers which may be bisected in more than one vertical plane.

acuminate, having a gradually diminishing point.

adnate, united with another organ or series, e.g., the ovary and calyx-tube.

adventitious buds, those produced elsewhere than in the axils of the leaves or the extremity of the branch.

alternate, applied to leaves, etc., inserted at different levels along the branch (as distinct from opposite).

anther, the part of the stamen which contains the pollen, usually divided into two pouches or thecae.

antheridium, the male sexual organ in non-flowering plants.

anthesis, the time when the flower is expanded.

apiculate, ending abruptly in a short point.

appressed, lying close and flat along the surface.

auriculate, having an ear-like lobe or appendage at the base of a leaf or other organ.

awn, a fine bristle usually terminating an organ (usually applied in the case of the flowers of grasses).

axil, the angle between the leaf and the branch; *axillary*, arising from the axil.

bract, a small, often modified leaf associated with the flower or the inflorescence.

bracteole, a small bract; a bract on the pedicel or close under the flower.

calyx, the outer envelope of the flower, consisting of sepals free or united; *calyx-tube*, when the sepals are partly united the lower portion is the tube and the upper free part is the *limb*, usually divided into *calyx-teeth*, *-lobes* or *-segments*.

campanulate, bell-shaped.

capitate, (1) like the head of a pin as the stigma of some flowers; (2) collected into compact head-like clusters (as the florets of *Compositae*).

capsule, a dry fruit composed of two or more united carpels, and either splitting when ripe into pieces called valves, or opening by slits or pores.

carpel, a simple pistil formed of a fruit-leaf folded lengthwise and with its edges united, or one of several such united to form a syncarpous ovary.

ciliate, with a fringe of hairs along the edge; *ciliolate*, minutely ciliate.

claw, the narrow base of a petal, etc.

compound, the opposite of simple; composed of several similar parts, as a leaf of several leaflets; *compound fruit*, when the fruits of separate flowers become united into a mass, as in *Morinda*; *compound umbel*, where each ray again bears an umbel.

connate, when parts of the same series are united so closely that they cannot be separated without tearing.

cordate, applied to the base of a leaf when it is more or less deeply notched.

corolla, the inner envelope of the flower, consisting of petals free or united.

crenate, the margin notched with regular blunt or rounded teeth.

crenulate, crenate with very small teeth.

culm, the stem of sedges and grasses.

cuneate, of the base of a leaf when tapering gradually, i.e., wedge-shaped.

cuspidate, abruptly tipped with a sharp rigid point.

decumbent, prostrate-ascending.

dehiscent, opening spontaneously when ripe, as capsules and anthers.

deltoid, shaped like an equal-sided triangle.

dentate, the margin prominently toothed, the teeth directed outwards.

denticulate, finely toothed.

digitate, a compound leaf whose leaflets diverge from the same point (the apex of the petiole), like the fingers of a hand (Bombax).

dioecious, with unisexual flowers, the male flowers on one individual and the female flowers on another.

ebracteate, without bracts.

ellipsoid, an elliptic solid.

elliptic, shaped like an ellipse, oblong with regularly rounded ends.

emarginate, notched at the extremity.

entire, with an even margin without teeth, lobes, etc.

falcate, curved like a scythe.

filiform, slender, thread-like.

flagellum, a whip-like thread.

follicle, a fruit formed from a single carpel opening usually only along the inner (i.e., ventral) suture to which the seeds are attached.

free, neither adhering nor united; *free-basal placenta*, one in which the ovules are attached to a central column arising from the base of the ovary-cavity and not reaching the top, e.g., *Primulaceae*; *free-central placenta*, the same, but reaching to the top of the cavity.

frond, the foliage of ferns.

glabrous, devoid of hairs; *glabrescent*, becoming glabrous or nearly so.

glumes, bracts, usually chaffy, in the spikelets of grasses and sedges.

gynoecium (pistil), the female part of the flower, consisting when complete of ovaries, styles and stigmas.

hyaline, almost transparent.

hypogynous, applies to the flower when the petals and stamens are inserted on the receptacle below the ovary and free from it, the ovary being thus *superior.*

imbricate, (1) overlapping like tiles; (2) in a flower-bud when one sepal or petal is wholly internal and one wholly external and the others overlapping at the edge only.

incised, cut rather deeply.

indehiscent, not opening when ripe.

indusium, an epidermal outgrowth covering the sori in ferns.

inflorescence, the arrangement of the flowers; *infructescence,* the inflorescence in the fruiting stage.

internode, the portion of stem between two nodes.

lamina, the limb, blade or expanded part of a leaf, sepal, or petal.

lanceolate, lance shaped, broadest about $\frac{1}{3}$ from the base.

lemma, the flowering glume of *Gramineae.*

ligule, (1) a thin, membranous appendage at the top of the leaf-sheath as in grasses; (2) the limb of ray-florets in *Compositae.*

linear, long and narrow with parallel edges.

loculus, the chamber or chambers of an ovary or fruit containing the ovules or seeds.

macrospore, the larger kind of spore in some ferns.

midrib, the principal usually central nerve of a leaf or leaf-like part.

monoecious, when the male and female flowers are separate, but borne on the same individual plant.

mucronate, ending abruptly in a short, stiff point which is a continuation of the midrib.

node, the place on the stem at which a leaf or leaves and accompanying organs arise.

oblanceolate, inverse of lanceolate.

oblate, transversely broadly elliptic.

oblong, longer than broad with more or less parallel sides.

obovate, ovate with the broadest part above.

obtuse, blunt or rounded at the end.

opposite, (1) of leaves or branches when two are borne at the same node on opposite sides of the stem; (2) of other organs, e.g., stamens, when opposite or placed in front of the petals instead of alternating with them.

orbicular, flat with a more or less circular outline.

ovary, that part of the pistil (the usually enlarged base) which contains the ovules and eventually becomes the fruit.

ovate, egg-shaped, of a flat surface which is scarcely twice as long as broad, with the broader end below the middle.

ovoid, solid shape of ovate outline.

ovule, the immature seed in the ovary before fertilization.

panicle, an inflorescence in which the axis is divided into branches bearing several flowers.

pedicel, the stalk of each individual flower of an inflorescence.

peduncle, the general name for a flower-stalk bearing either a solitary flower or a cluster, or the common stalk (rhachis, or axis) of several pedicellate or sessile flowers.

peltate, of a leaf of which the stalk is attached to its under-surface instead of to its edge.

perianth, the floral envelope, consisting of calyx or corolla, or both.

petal, the parts of the corolla.

petiole, the stalk of a leaf; *petiolule,* the stalk of a leaflet.

pinna, a primary division of a pinnate leaf; *pinnate,* of a compound leaf with the leaflets arranged along each side of a common rhachis.

pinnatifid, with the margin pinnately cleft.

pinnule, the secondary or tertiary division of a leaf which is twice or thrice pinnate.

plumose, feathered, as bristles which have fine hairs on each side, e.g., the pappus of some *Compositae.*

protoplasm, the viscous living substance of plant cells.

pseudovacuole, having the appearance of cavities in the protoplasm of cells.

puberulous, slightly pubescent.

pubescent, covered with short, soft hairs.

punctate, marked with dots or translucent glands.

pungent, ending in a sharp, rigid point.

raceme, an inflorescence in which the flowers are borne on pedicels along an unbranched axis or peduncle, the terminal flowers being the youngest and last to open (centripetal development).

radical, of leaves which arise so close to the base of the stem as to appear to proceed from the root.

ray, (1) the florets of the margin of a flower of the *Compositae* when different from those of the centre, or disk; (2) one of the radiating branches of an umbel.

receptacle, or *torus,* the extremity of the axis on which the parts of the flower, sepals, petals, stamens and pistil are inserted.

regular (*see* actinomorphic).

reticulate, net-veined, when the smallest veins of a leaf are connected together like the meshes of a net.

retrorse, bent abruptly backwards.

rhachis, (1) the principal axis of an inflorescence above the peduncle; (2) the axis on which the leaflets of a compound leaf are inserted; *rhachilla,* the rhachis of the spikelet in grasses and sedges.

rhizome, a rootstock or root-like stem prostrate on or under the ground, sending rootlets downwards and branches, leaves or flowering shoots upwards; always distinguished from a true root by the presence of buds, leaves or scales.

sagittate, of the base of a leaf with two acute, straight lobes directed downwards.

scabrid or *scabrous,* rough to the touch, usually from the presence of very short, harsh hairs.

scape, a naked flower-stalk.

scarious, thin and dry, not green.

sepal, the lobes or segments of the calyx.

septate, divided by one or more partitions.

serrate, toothed like a saw, with regular, pointed teeth.

serrulate, serrate with minute teeth.

sessile, without a stalk.

setose, beset with bristles.

setulose, a diminutive of setose.

sheath, the lower portion of the leaf clasping the stem.

simple, the opposite of compound; *simple leaf*, of one blade, not divided into leaflets.

sinuate, when the margin is uneven, with rather deep undulations.

sinus, (1) recess between the teeth or lobes on a margin; (2) angle formed by the basal lobes of a leaf or other organ.

sorus, a cluster of sporangia in ferns.

spadix, a flower-spike with a fleshy or thickened axis (e.g., *Araceae* and some palms).

spathe, a large bract enclosing a spadix, or one or more bracts enclosing a flower or inflorescence.

spike, an inflorescence with the flowers sessile along a simple, undivided axis or rhachis; *spicate*, arranged in a spike.

spikelet, in grasses and sedges, a small spike composed of one or more flowers enclosed by glumes.

spongiform, sponge-like.

sporangium, the spore-producing body in ferns.

spore, a single cell capable of direct development into a new plant, the analogue of a seed in the flowering plants.

sporocarp, a body containing spores.

stamen, the male organ of a flower containing pollen.

staminode, an abortive or vestigial stamen without a perfect anther.

stigma, the point or surface of the pistil which receives the pollen, either sessile (when there is no style) or on the top or surface of the style or its branches.

stipe, the stalk supporting a carpel, gynoecium, or frond in a fern.

stipules, leaf-like or scale-like appendages of a leaf, usually at the base of the petiole.

stolon, a runner which roots.

style, narrow upper part of an ovary supporting the stigma.

subulate, awl-shaped.

sulcate, grooved.

tepal, a division of an undifferentiated perianth.

tomentose, densely covered with short, soft, felted hairs.

torus (*see* receptacle).

trifoliate, three-leaved; *trifoliolate*, having three leaflets.

trigonous, obtusely three-angled.

triquetrous, with three sharp angles.

truncate, cut off more or less squarely at the end.

umbel, an inflorescence in which the divergent pedicels or rays spring from the same point; *compound umbel*, where each ray itself bears an umbel, each of the latter being called a *partial umbel, simple umbel*, where each ray terminates in a flower.

undulate, wavy on the margin.

utricle, applied (1) to the traps of *Utricularia*; (2) to the fruits of *Carex*, etc.

verticil, a whorl or arrangement of similar parts in a circle at the same level; *verticillate*, of leaves in a whorl or several arising at the same node arranged regularly around the stem.

villous, beset with long, weak hairs.

whorl (*see* verticil).

LIST OF COMMON NAMES OF HERBICIDES MENTIONED, WITH THEIR CHEMICAL ABBREVIATIONS

CMU	*see* monuron
2,4-D	2,4-dichlorophenoxyacetic acid
dalapon	2,2-dichloropropionic acid
DD	a mixture of 1,3-dichloropropane and 1,2-dichloropropane
diuron	N-(3,4-dichlorophenyl)-N^1,N^1-dimethylurea
kuron (2,4,5-TP)	2-(2,4,5-trichlorophenoxy)propionic acid
MCPA	4-chloro-2-methylphenoxyacetic acid
monuron	N-(4-chlorophenyl)-N^1,N^1-dimethylurea
PCP	pentachlorophenol
phygon-XL	2,3-dichloronapthoquinone
simazin	2-chloro-4,6-bis (ethylamino)-1,3,5-triazine
2,4,5-T	2,4,5-trichlophenoxyacetic acid
TCA	trichloroacetic acid

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VEGETATION TYPES OF SOUTHERN RHODESIA

by

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INTRODUCTION

The first attempt at classifying the vegetation of Southern Rhodesia was made by J. S. Henkel (1) in 1931 when he published his provisional map of the "Types of Vegetation in Southern Rhodesia'. He considered that the vegetation fell into two main physiognomic types, viz.: Grassland and Woodland, and these he subdivided further as follows:—

A. Grassland:—
  (i) Mountain Grassland;
  (ii) Plateau Grassland;
  (iii) Vlei (Valley) Grassland.

B. Woodland:—
  I. Closed Forest—
    (i) Mountain Forest;
    (ii) Fringing Forest.
  II. Open Forest—
    (i) (a) Muhatja *(Parinarium mobola)**[1];
      (b) Mangwe *(Terminalia sericea);*
      (c) Thorn *(Acacia* spp.);
    (ii) Mahobohobo *(Uapaca kirkiana);*
    (iii) (a) Msasa *(Brachystegia randii)**[2];
      (b) Umgusu *(Baikiaea plurijuga);*
    (iv) Mfuti *(Brachystegia woodiana)**[3];
    (v) Mopani *(Copaifera mopane)**[4].

In 1943, Pole Evans (2) in his "Report of Commission to enquire into the conditions prevailing, etc., in the pasturage of the Colony", described the vegetation as mostly Savanna and the remainder as Mountain Grassland and Mountain Forest. He classified the Savanna into three main types, viz.: (1) Orchard Country, (2) Woodland Country, and (3) Tropical Thornbush.

(1) The Orchard Country was that which occurred above 4,000 feet and was characterized by *Parinarium mobola**[1], *Terminalia sericea, Faurea saligna, Protea* spp., *Strychnos pungens, Acacia* spp., and in the area over 30 in. rainfall by *Brachystegia randii**[2].

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*[1] *Parinarium mobola* is now *Parinari curatellifolia* subsp. *mobola.*

*[2] *Brachystegia randii* is now *B. spiciformis.*

*[3] *Brachystegia woodiana* sensu Henkel is *B. boehmii.*

*[4] *Copaifera mopane* is now *Colophospermum mopane.*

(2) The Woodland Savanna Country was described at that occurring between 2,000 and 4,000 feet with such trees as *Brachystegia randii**[2], *Diospyros mespiliformis, Uapaca kirkiana, Berlinia globiflora**[3], *Afzelia quanzensis, Kigelia pinnata,* and, on the Kalahari Sands, *Baikiaea plurijuga.*

(3) The Tropical Thornbush occupied country below 2,000 feet and covered the low lying valleys of the Sabi, Limpopo and Zambezi Rivers. It was characterized by *Acacia* spp., *Commiphora* spp., *Sesamnothamnus lugardii, Copaifera mopane**[4], and *Adansonia digitata.*

The Mountain Grassland and Mountain Forest types occurred along the high country of the Eastern Border.

The grass cover of Southern Rhodesia was classified by Pole Evans into:— 1. Mountain Grassland, 2. Plateau Grassland, 3. Upland Grassland and 4. Tropical Valley Grassland.

1. The "Mountain Grassland" was not subdivided further although he suggested that distinct types depending on soil and other factors probably existed.
2. "Plateau Grassland" was divided into three main types, viz.: Matabele Highveld, Central Highveld, and Eastern Highveld. In the Matabele Highveld two distinct types were stated to occur, that on Basement Schist soils, and that on Granite Sands. In the Central Highveld he distinguished four subtypes, characterized by the presence of *Acacia* spp., *Brachystegia randii**[2], *Terminalia sericea,* and *Parinarium mobola**[1]. The Eastern Highveld was not subdivided further.
3. In the Upland Grassland he distinguished three distinct types, those on Kalahari Sands, those on Basement Schist soils and those on Granite Sands.
4. The Tropical Valley Grassland is described as varying considerably with soil type.

In 1957 Rattray (3) in "The Grasses and Grass Associations of Southern Rhodesia" states that, ecologically, Southern Rhodesia can be divided into three main vegetative regions only, viz.: Forest (of the closed Evergreen Type), Woodland, and Bushland or Thicket. The physiognomic terms employed were those decided upon by the Interterritorial Pasture Research Conference at Nairobi in 1940, which was appointed to draw up a classification of East African vegetation types, and which finally adopted a scheme which defined eight main physiognomic vegetation types. These were:—

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*[1] *Parinarium moboia* is now *Parinari curatellifolia* subsp. *mobola.*
*[2] *Brachystegia randii* is now *B. spiciformis.*
*[3] *Berlinia globiflora* is now *Julbernardia globiflora.*
*[4] *Copaifera mopane* is now *Colophospermum mopane.*

> (1) Forest, (2) Woodland, (3) Bushland and Thicket, (4) Wooded Grassland, (5) Grassland, (6) Permanent Swamp Vegetation, (7) Desert and Semi-desert, (8) Vegetation actually induced by man.

Rattray sub-divides the grass cover associated with these three vegetative regions provisionally into eight very broad types, viz.:

(1) Short Grass Mountain Grassland;
(2) Tall Grass *Hyparrhenia* Veld;
(3) *Hyparrhenia* — Other Species Veld;
(4) *Heteropogon* — Other Species Veld;
(5) *Eragrostis* — Other Species Veld;
(6) *Aristida*—Other Species Veld;
(7) *Cenchrus*—Other Species Veld;
(8) Short Grass Annual *Aristida—Dactyloctenium — Eragrostis* Veld.

As a result of a C.C.T.A./C.S.A. Conference of plant ecologists at Yangambi in 1956 a provisional physiognomic classification of the vegetation of Africa south of the Sahara (4) was drawn up and using this as a basis Boughey (6) considers that the vegetation types of the Federation can be classified as follows:—

I. *Closed Forest Formation*

A. Climatic Forest Formations

(a) Forests at low and medium altitudes.

1. Dry Deciduous Forests (*Baikiaea plurijuga* forests and possibly some Mopane woodlands).
2. Dry Evergreen Forest (*Cryptosepalum* Forests in Northern Rhodesia).
3. Thicket (Jesse thicket, Bamboo thicket, *Combretum—Commiphora-Kirkia-Pterocarpus* thickets in Northern Rhodesia. *Dichrostachys glomerata**[1] thicket, *D. nyassana**[2] thicket in Nyasaland, *Philippia* and *Smilax* thicket on Eastern Border of Southern Rhodesia).

(b) Forests at high altitudes. (Locally distributed as Mist, Gallery or Ravine Forest. Henkel's "Mountain Forest" on Eastern Border of Southern Rhodesia.

B. Edaphic Forest Formations

Riparian Forests (Rain Forest, Henkel's Fringing Forest, Jackson's "*Khaya nyassica* and *Adina microcephala* Fringing Forests", Swamp Forest of *Syzygium* spp. and *Raphia* Swamp).

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*[1] *Dichrostachys glomerata* is now *D. cinerea* subsp. *cinerea*.
*[2] *D. nyassana* is now *D. cinerea* subsp. *nyassana*.

II. *Mixed Forest-Grassland Formations and Grassland Formations*

- A. Woodland *(Brachystegia spiciformis, B. boehmii, Uapaca kirkiana).*

- A. Woodland *(Brachystegia spiciformis, B. boehmii, Uapaca kirkiana).*

- B. Savanna.
    1. Savanna Woodland *(Terminalia sericea, Parinarium mobola).*
    2. Tree Savanna (Species of *Acacia, Terminalia, Combretum,* with *Burkea, Faurea, Cussonia, Strychnos* and *Albizia,* are common types. This is the most extensive type in the Federation).
    3. Shrub Savanna *(Protea* spp. sometimes form this type).
    4. Grass Savanna (occur locally due to seasonal waterlogging).
- C. Steppe (Not found in the Federation).
- D. Grassland.
    1. Aquatic Grassland *(Vossia cuspidata* and *Echinochloa pyramidalis).*
    2. Herb Swamp (Wetter parts of vleis and *Papyrus* in Northern Rhodesia, and also *Typha* or *Phragmites* reed swamps. *Eriocaulon* and sedges such as *Scleria, Rhynchospora, Cyperus,* and *Kyllinga* also form communities which fall into this type.)
    3. High Montane Grassland. (Grassland of the mountainous Eastern Border. In Nyasaland *Loudetia simplex, Trachypogon spicatus, Exotheca abyssinica* and *Monocymbium ceresiiforme* form High Montane Grasslands.)

More recently Vincent and Thomas (7, 1960) have published a detailed classification for Southern Rhodesia in their Agro-ecological Survey. They have used the Nairobi terms referred to above but apart from this difference in nomenclature there is a strong basic relationship between their system and the one to be suggested here.

While the Yangambi classification appears to be fairly satisfactory for the higher rainfall types such as woodland and forest, the savanna types of the lower rainfall areas are not considered to be comprehensive enough and should include the various types of savanna of low stature which occur in this country. With this in mind and again using the Yangambi classification as a basis therefore, the following physiognomic types and their definitions are suggested for Southern Rhodesia:—

PHYSIOGNOMIC CLASSIFICATION

1. CLOSED FOREST FORMATIONS

Forest Types

Dry Montane Forest. A closed stand of tall evergreen trees often gymnospermous, with several strata of lower stature than, and not so well developed as, the moist Montane Forest; grass cover absent or a few shade loving species present only. Epiphytes and lianes absent or rare.

Moist Montane Forest. A closed stand similar to Moist Evergreen Forest but occurring at the higher altitudes and with smaller trees and a greater abundance of epiphytes. Occurs in patches under high rainfall conditions in the Eastern Districts.

Moist Evergreen Forest. A closed stand of tall evergreen trees with several strata including an upper stratum of large trees. Grass stratum absent or consisting of a few shade loving broad leaved species. Epiphytic bryophytes and lianes abundant (Eastern Districts).

Riparian Forest. Closed well grown stand of evergreen species giving permanent shade. Grass stratum absent or consisting of a few shade loving species. Along river banks (includes "Rain Forest" at Victoria Falls).

2. MIXED TREE-BUSH-GRASS FORMATIONS

(a) Woodland Types

Woodland. A fairly dense but open stand of deciduous trees usually over 20 ft. high with a canopy admitting a limited amount of light; tree stratum deciduous, either stratified with small or medium sized trees of the same or different species forming two or three lower layers, or unstratified, with trees all the same height. Grass cover sparse but fairly continuous, and often mixed with other herbs and shrubs.

(b) Savanna Types

Woodland Savanna. A more open stand of deciduous trees than the above, very often as a result of being cut-over; stratified or unstratified as in woodland. Grass cover continuous and somewhat better developed than in woodland proper. Trees over 20 ft. high. (In many cases Woodland Savanna is considered to be degraded Woodland.)

Tree Savanna. An open stand of deciduous trees often between 15 ft. to 20 ft. in height (or higher) with a well developed continuous grass cover which sometimes contains a number of herbaceous and/or small woody species. Unstratified or with an understorey of smaller specimens of the same species which could eventually grow into trees 15 to 20 feet tall if left undisturbed.

Tree/Bush Savanna. A fairly dense stand of deciduous trees with understorey of bushes (the trees up to 20 ft. or more—the bushes ranging from 5-15 ft.) with a well developed grass cover. The species of smaller trees and bushes are mostly different from the taller trees and are not likely to reach the same height. This type is therefore stratified and further stratification may result from the growth of scrubby types of plants 3-5 ft. high in which case this type may be called Tree/Bush/Scrub/Savanna or Tree/Scrub/Savanna. It seems necessary to include a type of this sort in order to distinguish between the unstratified tree savannas and those that are stratified, as the latter are often very extensive.

Bush/Savanna. An open stand of bushes (shrubs) up to 10-15 ft. in height with a well developed grass cover. Bushes generally more or less of the same height. Trees occasional and scattered.

Bush/Clump Savanna. Clumps of small trees or bushes forming islands in a good grass cover; occasionally a few taller trees in centre of clump. Clumps often associated with termitaria.

Bush/Scrub Savanna. An open stand of bushes and scrub (generally of the same species as the bush) ranging from 3-4 ft. high (the scrub) to 10 - 15 ft. high (the bush), with a well developed grass cover. Very often this type has been derived by cutting-over the bush/savanna type.

Scrub/Savanna. A stand of varying density of small shrubs or bushes, sometimes stunted or malformed by fire or frost, up to 6 ft. high in a well developed grass cover.

(c) Thicket Types

Bushland or Thicket. A dense stand of small trees (up to 15 ft. high or more) or bushes or shrubs which may or may not be spiny; grass cover virtually absent or very sparse. Thickets may also often be formed by coppice growth.

3. GRASSLAND FORMATIONS

Grassland Types

Grassland. Land covered with grasses and other herbs, sometimes with very scattered trees, which are generally along stream banks or in water courses, on antheaps, or along the margins of vlei grasslands. This includes the edaphic grasslands or "vlei" types with a wetness of varying periods and severity, and secondary grasslands brought about by biotic factors.

It will be noticed that the word "bush" has been used to define certain types of savanna rather than the more botanically correct term "shrub" which is used in the Yangambi classification. This has been done largely because of the extremely wide usage of the word "bush" in Southern Africa to denote certain types of vegetation which contain small trees, bushes and shrubs in varying proportions mostly branching from near ground level and of low stature. The accepted definition of a "shrub" is a woody perennial, smaller than a tree, but branched from the ground with no evident main trunk, whereas a "bush" is merely regarded botanically as a small shrub. It was therefore thought that using the word "bush" instead of "shrub" in the descriptions of certain of the savanna types would be more widely acceptable locally as it was a term already in existence (bushveld, bushland, bush, thornbush) and would not represent any great change in present terminology. In the Union of South Africa the term "shrub" may probably be more effectively used in describing some of the Karroo types of vegetation particularly the "dwarf shrub" type.

The use of the word "savanna" as recommended at Yangambi will probably be accepted with a certain amount of reluctance by many workers but it does seem to be a very useful term for describing a type of vegetation which is comprised of woody plants of varying heights and densities standing in a well-developed grass cover. By contrast the term "woodland" indicates a vegetation type which has a very high preponderance of well-grown trees forming a more or less closed canopy and a sparse but fairly continuous grass cover. Forest differs from woodland in having a closed canopy and either no grasses at all, or only a few scattered grasses never forming a continuous cover. Degraded forest may exist as woodland, or, in extreme cases, as a savanna of some sort, and woodland itself may also be degraded to a savanna type. Some of the savanna types described above such as bush savanna, bush/scrub savanna and scrub savanna may often represent seral stages in the secondary succession from old fallows or clearings to a woody-plant climax of savanna or woodland. All over Southern Rhodesia, or for that matter, Africa itself, the biotic influences of livestock, man and fire have greatly influenced the development of the natural vegetation and many different stages in the succession are now apparent. Certain parts of this country, alleged to have been cleared of the woody vegetation 70-100 years ago, have remained open grassland, while others are slowly reverting back to the climax vegetation or have been halted for one reason or another at a particular stage in the succession. On the other hand, the colonization of other previously open areas has proceeded with alarming rapidity, and dense thickets, particularly of thorny species, have developed within a period of 10-20 years, providing bush encroachment problems of some considerable magnitude. These statements can be readily substantiated not only by the recollections of early settlers but also by consulting the nineteenth century paintings of Thomas Baines of well known Rhodesian localities. Shantz and Turner's (6) series of photographs of African vegetation with a thirty-year interval are also very revealing in this respect.

FLORISTIC CLASSIFICATION

The main physiognomic types of vegetation occurring in this country then are Forest, Woodland, Savanna, Thicket and Grassland, but these can be further subdivided on a floristic basis according to their botanical composition. Thus:—

1. FORESTS

A. Dry Montane Forest

Podocarpus type. Evergreen forest with a closed canopy characterized by *Podocarpus milanjianus* and *Widdringtonia whytei* and associated with a number of other tree species such as *Curtisia faginea, Cussonia umbelifera, Ilex mitis, Macaranga mellifera, Xymalos monospora,* forming three or four strata. Shrubs and bushes of *Leucosidea sericea, Philippia benguelensis, Cnestis natalensis,* and *Hypericum revo-*

lutum are often found as fringing species. The forest floor is often densely covered with ferns, herbaceous plants and a few shade-loving grasses. Occurs in small patches in the high altitude—high rainfall (including mist) areas of the Eastern Districts, surrounded by open grassland.

B. Moist Montane Forest

Macaranga Type. Evergreen forest with a closed canopy, characterized by *Macaranga mellifera, Rapanea melanophleos, Albizia gummifera, Ilex capensis, Trimeria rotundifolia, Pittosporum viridiflorum,* and *Dovyalis lucida.* Occurs at higher altitudes than Moist Evergreen Forest.

C. Moist Evergreen Forest

Khaya type. Evergreen forest with a closed canopy, and consisting of taller trees (up to 200 ft. high) than Dry Montane Forest; characterized by *Khaya nyasica, Adina microcephala, Lovoa swynnertonii* and a number of other tree species such as *Diospyros abyssinica, Trichilia chirindensis, Tannodia swynnertonii, Chrysophyllum gorungosanum* and *Strychnos mitis.* Smaller tree species are also associated forming several strata. Species of *Dracaena* are common in the lower stories. Forest floor contains numerous mosses and ferns and several shade loving species of grasses such as *Pseudoechinolaena polystachya, Chloachne oplismenoides* and *Oplismenus hirtellus.* Occurs at the lower altitudes, but with high reliable rainfall, in the Eastern Districts. (Largely found at Mt. Selinda.)

D. Riparian Forest

(1) At medium to high altitudes.

Ilex type. Evergreen forest fringing rivers and streams at altitudes generally above 4,000 ft. Characterized by such species as *Ilex mitis, Syzgium cordatum, Bequaertiodendron magalismontanum* and *Mimusops kirkii,* often associated with *Myrica aethiopica, Pittosporum viridiflorum* and others. Small trees and bushes occur in the understorey, and a few shade loving species of grasses such as *Setaria* sp. are found in the forest floor.

(2) At medium altitudes.

A good example of fringing evergreen forest at medium altitudes (3,000-4,000 ft.) is the "Rain Forest" at Victoria Falls on the Zambezi at an altitude of about 3,000 ft. This, however, is developed in some depth and is richer than usual in species. Such species as *Diospyros mespiliformis, Mimusops zeyheri, Ficus mallotocarpa, F. capensis, Syzygium guineense, S. cordatum, Trichilia emetica,* and *Strychnos stuhlmannii* are common and the understory includes *Pavetta cataractarum, Feretia aeruginescens* and other shrubs. Many herbs occur on the forest floor and the palm *Phoenix reclinata* is found on the drier fringes.

(a) *Trichilia type*. Evergreen forest fringing rivers and streams at altitudes generally below 3,000 ft. and characterized by *Trichilia emetica, Conopharyngia elegans* and *Kigelia pinnata*. Commonly associated tree species are *Ficus gnaphalocarpa*, and *Ostryoderris stuhlmanni*. Shrubs and bushes such as *Grewia inaequilatera, G. sulcata* and *Acalypha ornata* and the lianes *Taccazea apiculata* and *Artbotrys brachypetalus* form a dense understorey. Little ground-cover exists.

Species of *Acacia* (such as *A. albida, A. polyacantha* subsp. *campylacantha*, and *A. galpinii)* may also be very common at times, as well as *Syzygium* spp. and *Lonchocarpus capassa*. Other species which may be commonly associated are *Diospyros mespiliformis, Cordyla africana*. Small trees, shrubs and lianes form an understory. A few shade-loving species of grasses such as *Cymbosetaria sagittifolia* and *Brachiaria deflexa* are sometimes found on the forest floor.

(b) *Adina type*. Dense evergreen forest in the hot valleys of the Eastern Districts where the rainfall is high, of *Adina microcephala, Khaya nyassica, Anthocleista zambesiaca* and *Trichilia chirendensis*.

2. WOODLANDS

(a) *Brachystegia spiciformis types*. Deciduous woodland 20-40 ft. high of *Brachystegia spiciformis* alone or more frequently in association with *Julbernardia globiflora* or *Brachystegia boehmii* or both. On the Eastern Border *Brachystegia utilis* sometimes replaces *B. spiciformis*. Other tree species which may occur are *Faurea saligna, F. speciosa, Combretum molle, Uapaca kirkiana, Pterocarpus angolensis, Albizia antunesiana, Strychnos spinosa, S. pungens, Monotes glaber* and *Gardenia spatulifolia*. *Brachystegia tamarindoides* occurs on rocky hills and ridges. On Kalahari sands, often associated with *Baikiaea plurijuga* and *Pterocarpus angolensis*. Although largely stratified in Northern Rhodesia, where it occurs most commonly under higher rainfall conditions than in this country, this type of woodland in Southern Rhodesia is generally unstratified or has only a few small bushes as an understory. The grass cover is sparse and includes such species as *Hyparrhenia filipendula, H. dissoluta, Brachiaria brizantha, Pogonarthria squarrosa, Rhynchelytrum nyassanum, Craspedorhachis rhodesiana* and *Eragrostis* spp. In the high rainfall areas of the Eastern Districts *Loudetia simplex* is a common species. Occurs most commonly in 30-45 in. rainfall areas above 4,000 ft. on several soil types but always in well drained sites.

(b) *Brachystegia boehmii types*. Deciduous, and usually unstratified, woodland 20-40 ft. high of *Brachystegia boehmii* alone or more frequently in association with *Julbernardia golbiflora*, and, at the higher altitudes, with *Brachystegia spiciformis*. As this type of woodland commonly occurs on the escarpments, below the plateaux where *Brachystegia spiciformis* predominates, at altitudes between 3,000 ft. and 4,000 ft., *B. boehmii* flourishes under warmer and drier conditions than the latter, and common tree associates include *Piliostigma thonningii, Monotes engleri, Afrormosia angolensis, Afzelia quanzensis, Combretum* spp., *Diospyros mespiliformis, Peltophorum africanum, Kirkia acuminata, Acacia* spp. and others. *Brachystegia allenii* is common on the Zambezi escarpment and frequently produces hybrid populations with *B. Boehmii*. At the lower altitudes *B. boehmii* often merges with *Colophospermum mopane* woodlands or savannas on granite sands. The grass cover is sparse and similar to that associated with *Brachystegia spiciformis*, but on heavy red soils derived from dolerite or epidiorite it may be better developed and *Themeda triandra, Heteropogon contortus* and *Setaria sphacelata* are more common. Pure communities of *Brachystegia boehmii* are sometimes found at altitudes above 4,000 ft. in the *B. spiciformis* zone and are then very often indicative of stony, gravelly, poor soils with a tendency to waterlogging in wet spells.

(c) *Julbernardia globiflora types*. Deciduous, usually unstratified woodland, 20-40 ft. high, of *Julbernardia globiflora* alone or more commonly in association with *Brachystegia spiciformis* or *B. boehmii*. As *Julbernardia globiflora* has a wider altitudinal range than either of the above *Brachystegia* species it may often be found in relatively pure communities at the lower altitudes where climatic conditions are less favourable for these species. Under such warm and drier conditions *Julbernardia* may also be associated with *Colophospermum mopane, Kirkia acuminata*, and *Sclerocarya caffra*, or with *Terminalia sericea* and *Burkea africana*, but in these circumstances the trees tend to open out somewhat and the physiognomy then often changes to a woodland savanna or even to a tree savanna.

Small trees and bushes sometimes form a well developed understory but generally *Julbernardia* woodland is unstratified.

The grass cover is very sparse and the same species of grasses occur as are found under *Brachystegia* woodlands under the higher rainfall conditions. Where conditions are drier however, *Heteropogon contortus* and species of *Eragrostis* and *Aristida* become more common.

(d) *Parinari curatellifolia types*. Evergreen unstratified woodland, 30-40 ft. high, of pure communities of *Parinari curatellifolia*. Usually occurs on sandy soils with a high water-table and where the effective rainfall is between 30 in. and 45 in. annually. These woodlands are now very limited in extent and have generally been degraded to savanna by clearing and burning (see also type 3Ba).

Henkel considers that *Parinari* woodland covered the whole of the main plateau at one time and that it has been extensively invaded by *Brachystegia* species in the east and *Baikiaea plurijuga* in the west. Species of *Faurea* and *Protea* are often found fringing this type of woodland.

The grass cover is sparse and in some cases absent, being replaced by herbaceous shade tolerant species.

(e) *Uapaca kirkiana types*. Deciduous unstratified woodland 20-40 ft. high of pure communities of *Uapaca kirkiana* usually of limited extent; more commonly found in association with *Brachystegia spiciformis*, at altitudes above 4,000 ft., where the annual rainfall is above 30 in.

This type of woodland is generally situated on rocky, well drained soils in frost free areas. Henkel considers that it at one time covered extensive areas which are now occupied by *Brachystegia spiciformis.*

In the hot valleys of the Eastern Border where the rainfall is high *Uapaca kirkiana* forms a tall dense woodland approaching dry deciduous forest. The grass cover is generally very sparse or absent; when present, *Andropogon* spp. and *Hyparrhenia* spp. are common. Frequently, as in the Honde Valley, the *Uapaca* is associated with thickets of *Oxytenanthera abyssinica.* Both the *Uapaca* and the bamboo form part of the succession towards evergreen forest.

(f) *Baikiaea plurijuga types.* Deciduous woodland over 25 ft. high which is considered to be derived from Dry Deciduous Forest, and dominated by *Baikiaea plurijuga* usually in association with *Pterocarpus angolensis* and *Guibourtia coleosperma.* Occurs exclusively on Kalahari sand with an annual rainfall of about 20-28 in.

Other common tree associates include *Brachystegia spiciformis, Brachystegia boehmii, Julbernardia globiflora, Afzelia quanzensis, Dialium engleranum, Ochna pulchra, Ricinodendron rautanenii, Kirkia acuminata, Burkea africana, Erythrophleum africanum, Combretum* spp., and *Commiphora* spp. This type of woodland is often stratified with numerous small trees and bushes such as *Paropsia brazzeana* and *Baphia obovata,* and also as a result of secondary growth after the timber trees have been cut out.

The grass cover is very sparse but generally consists of tall species of *Aristida* (such as *A. graciliflora* var. *robusta,* and *A. pilgeri), Triraphis schlechteri, Tristachya rehmannii, Digitaria* spp., and *Eragrostis* spp.

The area occupied by these *Baikiae*a woodlands was, according to Henkel, originally dominated by *Parinari curatellifolia,* but this species has in the course of time given way to *Baikiaea,* and this in turn is now being invaded by the two *Brachystegia* species and *Julbernardia globiflora.*

(g) *Pterocarpus angolensis types.* Deciduous woodland over 25 ft. high dominated by *Pterocarpus angolensis* in association with *Guibourtia coleosperma* or *Brachystegia spiciformis* or both. It occurs on Kalahari sand under very much the same conditions as the *Baikiaea* woodland and the same tree associates such as *Afzelia, Burkea, Julbernardia, Combretum,* etc., are present. It often merges with *Colophospermum* types. In some localities it might be considered as a variant of the *Baikiaea* type from which the *Baikiaea* itself is absent probably as a result of extensive cutting, in other instances it probably forms natural communities within the *Baikiaea* type. The grass cover is sparse but commonly includes tall *Aristida* spp., *Triraphis schlechteri* and *Digitaria* spp., except when *Brachystegia spiciformis* is the main associate. *Andropogon* sp. then very often becomes more frequent.

Small trees and bushes often form a fairly dense understorey.

(h) *Colophospermum mopane types.* Deciduous woodland of pure or almost pure communities of *Colophospermum mopane* 20-50 ft. high on deep well drained soils at altitudes below 3,000 ft. with an annual rainfall of less than 24 in. Other physiognomic types, dominated by *Colophospermum,* occur extensively even up to altitudes of 4,000 ft. and a rainfall of 25-30 in., but these are generally woodland savannas, tree savannas or, probably more commonly, tree/bush savannas. Where the *Colophospermum* is tall and well developed with an almost closed canopy, there is usually no understory of any sort and no grass cover. In the Sabi Valley however, dense Mopane woodland often has an understorey of shrubby *Grewia bicolor.*

It is often difficult to determine where the *Colophospermum* woodland types change to woodland savannas as there is considerable variation in tree density. In the north, for example, under higher rainfall conditions the Mopane country in the Zambezi Valley varies between woodland and woodland savanna whereas in the drier south woodland savanna, tree savanna and tree/bush savanna types are more common.

3. SAVANNAS

A. Woodland Savannas. Deciduous stratified or unstratified woodland savannas of various types. Where conditions either climatically or edaphically are not quite favourable enough to support a tall, dense, well developed woodland, the tree spacing becomes wider, a better grass cover develops, and more small trees, bushes, and herbaceous plants appear in the understory. Again too, as a result of partial clearing for cultivation or cutting for timber or firewood many of the woodlands, except the *Parinari* type, have been degraded in certain areas to woodland savanna, and it is often difficult to decide where the woodland itself merges into the more open savanna type. Where the *Parinari* woodland has been cut-over it seems to have developed into a tree savanna and is very much more open and park-like in appearance than a woodland savanna.

The canopy of a woodland savanna although slightly more open than that of a woodland, is still sufficient to cast a fair amount of shade and thus prevent the grasses from reaching their maximum development. Woodland savannas, typified by the genera *Brachystegia, Julbernardia, Uapaca, Baikiaea, Pterocarpus,* or *Colophospermum,* therefore occur under somewhat the same conditions as the woodlands or on their drier margins, but are often not as tall. The tree associates are also similar in many respects to those found in the woodlands, but there may be more secondary growth present as a result of cutting. The same species of grasses that are associated with the woodlands are also found in the woodland savannas but there may be additional species as well where disturbance of the soil has taken place.

B. Tree Savannas. Deciduous or evergreen unstratified savannas of various types.

(a) *Parinari curatellifolia types.* Open, evergreen tree savanna of *Parinari curatellifolia,* over 20 ft. high (very often derived from woodland) with a conspicuous grass cover, and occurring on sandy soils with poor drainage and a high water table, or on the margins of some edaphic grasslands. Most commonly found on the main plateau at altitudes above 4,000 ft. and where the rainfall is more than 24 in. annually, e.g., in the Enkeldoorn, Umvuma and Somabula areas.

Faurea speciosa, Protea gaguedii, P. angolensis, Cussonia spicata, Strychnos spp., are sometimes associated with the *Parinari* particularly on the fringes.

The grass cover generally contains a mixture of dryland and moisture loving species depending on the soil moisture status. Thus *Hyparrhenia* spp., *Cymbopogon* sp., *Andropogon schinzii, Chloridion cameronii, Brachiaria nigropedata* and other dryland species may be found in varying proportions with such species as *Loudetia simplex, Pennisetum* sp., *Schizachyrium* spp., *Alloteropsis semialata,* and several others.

(b) *Terminalia sericea types.* Deciduous tree savanna up to about 25 ft. high, and of varying density, or *Terminalia sericea* in association with *Burkea africana,* on granite or gneissic sands at altitudes between 3,500 ft. and 4,500 ft. where the rainfall is 20-24 in. annually.

At times the *Terminalia* may form almost pure communities while at others it would appear that *Burkea* is dominant. On the whole, however, it is perhaps more common to find a number of tree species associated with these two genera, very often forming a tree/bush savanna type. Some of these are *Heeria insignis, Peltophorum africanum, Protea gaguedii, Faurea saligna, Lannea discolor, Ficus capensis, Rhus lancea, Pseudolachnostylis maprouneifolia, Pterocarpus angolensis, Dombeya rotundifolia, Piliostigma thonningii, Bolusanthus speciosus, Combretum* spp., and a number of others. As the rainfall becomes less *Sclerocarya caffra,* and *Kirkia acuminata* sometimes become more frequent and eventually *Combretum* spp. or *Colophospermum mopane* or both, appear, and may ultimately become the dominant trees of the savanna.

The grass cover is good and where the rainfall is in the region of 24 in. annually, *Hyparrhenia filipendula, H. dissoluta, Chloridion cameronii, Schizachyrium semiberbe, Pogonarthria squarrosa, Heteropogon contortus* and *Digitaria* spp. are common, while towards the drier parts, *Eragrostis rigidior, E. gummiflua* and *E. superba,* become more abundant than the *Hyparrhenia* spp.

(c) *Combretum spp. types.* Deciduous tree savanna of varying density up to 30 ft. high (often including areas of tree/bush savanna) dominated by species of *Combretum.*

(1) In the 24-28 in. rainfall zone at altitudes between 3,500 ft. and 4,000 ft. on heavy soils often with poor drainage, *Combretum ghasalense, C. imberbe* and *C. hereroense* are the dominant species. *Piliostigma thonningii, Dalbergia melanoxylon* and *Albizia* spp. are also common in this type of savanna which may adjoin *Julbernardia globiflora,*

Brachystegia boehmii, and *Colophospermum mopane* types. *Acacia* spp. occur along the drainage lines.

The grass cover is usually of the *Hyparrhenia-Heteropogon* type with *Andropogon schinzii, Chloridion cameronii, Pogonarthria squarrosa, Eragrostis* spp., and *Aristida* spp. also common.

(2) In the granite areas of the 20-24 in. rainfall zone, at altitudes between 3,500 ft. and 4,000 ft., *Combretum apiculatum* and *Terminalia sericea* form an open tree savanna, with such other species as *Sclerocarya caffra, Acacia* spp., *Heeria reticulata, Strychnos* spp., *Gardenia* spp. and *Rhus lancea* common.

Here the grass cover is predominantly *Heteropogon contortus* and *Hyparrhenia* spp. with *Eragrostis* spp. and *Cymbopogon* sp. associated.

(d) *Acacia spp. types.* Deciduous tree savannas of varying density up to 30 ft. high (often including areas of tree/bush or scrub savanna) dominated by one or more species of *Acacia* (largely depending on soil type) such as *A. nigrescens, A. tortilis* subsp. *heteracantha, A. karroo, A. nilotica* subsp. *kraussiana, A. mellifera* subsp. *detinens, A. gerrardii, A. rehmanniana, A. polyacantha* subsp. *campylacantha* and *A. giraffae*. These occur largely where the rainfall is below 25 in. annually.

(1) On Kalahari Sands in 20-24 in. rainfall areas, *Acacia giraffae* forms extensive tree savannas. The grass cover consists largely of tall perennial *Aristida* spp., *Eragrostis pallens, Digitaria* sp. and *Panicum* sp.

(2) On basement schists in 20-24 in. rainfall areas *Acacia gerrardii* together with *A. nilotica* subsp. *kraussiana, A. karroo* and *A. rehmanniana* form a characteristic tree savanna which, depending on biotic influences, may include tree/bush savanna types as well as a certain amount of secondary scrub growth.

A number of other trees are often associated such as *Combretum apiculatum, C. hereroense, Ormocarpum trichocarpum, Sclerocarya caffra* and *Peltophorum africanum*.

The grass cover is predominantly *Themeda triandra* in association with *Heteropogon contortus, Cymbopogon plurinodis, Eragrostis* sp. and *Bothriochloa insculpta*.

(3) On heavy black clay soils derived from basalt in 20-24 in. rainfall areas *Acacia nilotica* subsp. *kraussiana* often occurs as a well grown open tree savanna.

The grass cover is predominantly *Setaria porphyrantha* with *Dichanthium papillosum, Sorghum versicolor, Bothriochloa insculpta* and *Panicum maximum* associated.

(4) On deep colluvial soils of the Zambezi Valley with a rainfall of 20-24 in. *Acacia tortilis* subsp. *heteracantha* forms extensive areas of tree savanna. An understory of shrubs is often present and the grass cover includes species of *Eragrostis, Aristida* and *Urochloa* and *Dactyloctenium aegyptium*.

(5) On heavy black clays derived from basalt in the Sabi Valley with a rainfall of 12-16 in. *Acacia nigrescens* in pure stands or with *Sclerocarya caffra* co-dominant forms a well developed open tree savanna. Shrubs such as *Flacourtia indica, Securinega virosa, Bridelia mollis* and *Combretum* spp. occur scattered throughout. The grass cover is characterized by *Setaria mombassana, Ischaemum brachyatherum, Sorghum versicolor* and *Brachiaria eruciformis.*

(6) On deep sandy soils derived from sandstones of the Permian system in the Sabi Valley in the 12-16 in. rainfall zone *Acacia nigrescens,* together with *Colophospermum mopane, Sclerocarya caffra* and *Commiphora* spp., form a tree savanna which includes areas of tree/bush savanna on account of the presence of such small tree and bush species as *Phyllanthus discoideus, Pteleopsis anisoptera, Heinsia crinita* and *Strophanthus kombe.*

The grass cover here consists mainly of *Panicum maximum, Cenchrus ciliaris, Pogonarthria squarrosa, Digitaria pentzii, D. perrottettii, Enteropogon macrostachyus* and *Aristida* spp.

(e) *Colophospermum mopane types.* Deciduous tree savannas of varying densities up to 38 ft. high or more, of *Colophospermum mopane* alone, or in association with a number of other trees, the chief genera of which are *Acacia, Combretum, Sclerocarya, Brachystegia, Kirkia, Adansonia* and *Commiphora.* The most typical of the tree savanna types are usually on undisturbed sites of *Colophospermum* alone and the physiognomy becomes more of the tree/bush type when mixed with other species and where disturbance has taken place.

Colophospermum mopane is dominant or co-dominant, over extensive areas of savanna in the south of Southern Rhodesia particularly where the rainfall is below 20 in. These savannas occur on a number of soil types but are best developed on those that are sandy, fairly deep and well-drained. Where the soils are heavy and badly drained the trees become small or stunted, and when the sub-soil is compacted and strongly alkaline with a high exchangeable sodium content the trees become scrub-like and the grass cover is absent or consists of only a few ephemeral annuals. These bare "Sikwakwa" patches are common in granite soils at the higher altitudes and where the rainfall is about 20 in. annually. Where the *Colophospermum* savanna reaches its maximum development the grass cover is good and may vary from one which is predominantly perennial to one which is almost entirely annual depending largely on past management or treatment. Common perennials are *Eragrostis rigidior, Cenchrus ciliaris, Schmidtia bulbosa* and *Urochloa* spp., while the annuals are *Enneapogon cenchroides, Aristida adscensionis, Eragrostis viscosa, Dactyloctenium aegyptium* and *Urochloa* spp.

Although *Colophospermum* is frequently associated with other trees to form a tree savanna type of vegetation these types are perhaps not so extensive as the tree/bush type with Mopane as dominant, and which is frequently described as "mixed bush". It has been thought desirable therefore to describe the variants of this type under the heading of Tree/Bush Savanna.

However, the following tree savanna types of *Colophospermum* may be recognized:—

1. *Colophospermum* alone—*Eragrostis* (Kalahari, Permian).
2. *Colophospermum—Brachystegia boehmii—Aristida* (Kalahari).
3. *Colophospermum—Acacia—Combretum—Cenchrus* (Basalt).
4. *Colophospermum — Commiphora — Adansonia — Aristida* (annual) (several soil types).

(f) *Hyphaene ventricosa types.* This palm forms a subriverine savanna zone along the drier margins of evergreen riparian forest (see D2a) in the Sabi, Limpopo, Shashi and Zambezi Valleys.

C. Tree/bush savannas. Deciduous stratified tree savannas of various types, the stratification resulting from adult bushes of different species of varying stature, or from secondary growth of cut-over trees.

(a) *Acacia types.*

(1) A deciduous tree/bush savanna of varying density up to 25 ft. high of *Acacia nigrescens* and *Combretum apiculatum* together with such trees and bushes as *Acacia nilotica* subsp. *kraussiana, A. karroo, A. rehmanniana, A. gerrardii, Dichrostachys cinerea, Rhus lancea, Peltophorum africanum, Ziziphus mucronata, Bolusanthus speciosus, Lannea discolor, Grewia* spp., *Euclea* spp., *Piliostigma thonningii* and others.

It occurs in the 20-24 in. rainfall zone on the basement schist soils at altitudes between 3,500 and 4,000 feet.

The grass cover is dominated by *Heteropogon contortus* in association with *Themeda triandra, Cymbopogon plurinodis, Eragrostis superba, Bothriochloa insculpta, Digitaria* spp. and several others. (See also type (2) of the *Combretum* tree/bush savanna where the composition is similar but dominance differs.)

(2) A type very similar in composition to the above but occurring at altitudes between 2,000 and 3,500 feet with a 16-24 in. rainfall, and mainly on soils derived from Paragneiss; including *Colophospermum mopane* as a common species.

The grass cover is different in that *Eragrostis* spp., particularly *E. rigidior*, take over dominance from *Heteropogon contortus*, and *Urochloa mossambicensis, U. pullulans, Cenchrus ciliaris* and *Schmidtia bulbosa* are common.

(3) An open, tree/bush type, of *Acacia mellifera* subsp. *detinens* and *Combretum imberbe* on Kalahari sand in the 20-24 in. rainfall zone. The grass cover includes species of *Setaria, Andropogon* and *Dichanthium.*

(4) A common tree/bush type at altitudes between 1,500 ft. and 2,500 ft. and rainfall of 12-16 in. (particularly in the Sabi Valley) which varies slightly according to soil type is the combination of *Acacia* spp. with *Colophospermum mopane, Adansonia digitata, Sclerocarya caffra, Commiphora mollis* with and without species of *Grewia*. (*Acacia nigrescens* is perhaps the commonest *Acacia*.)

Other tree species which may occur are *Afzelia quanzensis, Euphorbia ingens, E. cooperi* and *Peltophorum africanum.*

The grass cover generally comprises *Enneapogon cenchroides, Urochloa* spp., *Panicum maximum, Dactyloctenium aegyptium, Chloris myriostachya, Cenchrus ciliaris, Aristida* spp. and *Eragrostis* spp.

(b) *Terminalia sericea type.* A tree/bush savanna, 20-25 ft. high, at altitudes of about 3,000-3,500 ft. and a rainfall of 20-24-in. annually, largely on granite sands, dominated by *Terminalia sericea* with *Colophospermum mopane* on the less well drained sites. Common tree and bush associates are *Piliostigma thonningii, Burkea africana, Sclerocarya caffra, Combretum* spp., *Peltophorum africanum, Strychnos innocua, Diospyros mespiliformis, Pseudolachnostylis maprouneifolia,* and *Kigelia pinnata.*

The grass cover is predominantly *Heteropogon contortus* and *Eragrostis rigidior,* with such other species as *Pogonarthria squarrosa, Urochloa* spp., *Digitaria* spp., and *Bothriochloa insculpta.*

(c) *Combretum spp. types.*

(1) A tree/bush savanna type, 20-25 ft. high, at altitudes of about 4,000-4,500 ft., with a rainfall of 20-24 in. annually on red clay soils of the basement schists dominated by *Combretum apiculatum* in association with *Acacia nigrescens, A. gerarrdii, A. rehmanniana, A. nilotica* subsp. *kraussiana.*

Other common trees are *Sclerocarya caffra, Pappea capensis, Kirkia acuminata, Ormocarpum trichocarpum, Bolusanthus speciosus, Peltophorum africanum* and *Commiphora mollis. Acacia karroo* occurs along the drainage lines.

The grass cover is predominantly *Heteropogon contortus* and *Themeda triandra,* together with *Cymbopogon plurinodis, Panicum maximum, Chrysopogon montanus* var. *tremulus,* and *Eragrostis* spp.

Parts of this type of tree/bush savanna could be described as tree savanna in the more undisturbed areas, but there appears to have been a considerable amount of cutting over for firewood and poles in many areas and the secondary growth which has resulted has now brought about the appearance of a tree/bush savanna.

(2) A tree/bush savanna, 20 ft.-25 ft. high, at altitudes of between 2,500 and 3,500 feet and a rainfall below 20 in. annually, and dominated by species of *Combretum* such as *C. apiculatum, C. hereroense,* and *C.*

imberbe in a very mixed association of trees and bushes consisting largely of *Colophospermum mopane, Terminalia sericea, Sclerocarya caffra, Acacia nigrescens, Kirkia acuminata, Afzelia quanzensis, Grewia* spp., and *Albizia* spp.

The grass cover is dominated by species of *Eragrostis* such as *E. rigidior, E. superba, E. jeffreysii* and *E. gummiflua,* and other common species are *Brachiaria nigropedata, Urochloa pullulans, Pogonarthria squarrosa,* and *Digitaria* spp.

As in *Combretum* type (1) much of the bush growth may be secondary but species of *Grewia* also contribute largely to the bush constituents of the savanna.

(d) *Colophospermum mopane types.* As mentioned under the *Colophospermum* woodland types, in the northern part of the territory this species is very extensively found forming woodlands and woodland savannas. It is also likely that in some areas the physiognomy might best be described as tree, or tree/bush savanna, but such areas would not be very large, and it is in the south, where the country drains into the Limpopo and Sabi Rivers that the Mopane forms the more open tree and tree/bush savanna types. However, even here the density of the woody plants varies considerably and patches of woodland and woodland savanna may sometimes occur within the tree and tree/bush savanna types.

These Colophospermum tree/bush savannas occur most commonly where the rainfall is below 20 in. annually and at altitudes from 3,000 feet to where the rainfall is below 20 in. annually and at altitudes from 3,000 feet to below 1,000 feet, although they may also be found at higher altitudes as well. Under these conditions, however, the Mopane is usually sub-dominant to species of *Combretum* or *Acacia* or *Terminalia.* The size and development of the trees depends largely on the soil types as mentioned under the *Colophospermum* tree savannas. Thus, trees are small and stunted on shallow basalt soils.

Covering as they do, a wide range of climatic and edaphic conditions, these tree/bush savanna types might be expected to vary considerably in their botanical composition but this is not actually the case. Many of the associated species are common throughout and it is often only their frequency that varies with rainfall and soil, although, of course, other minor species do appear or disappear as well. Thus *Sclerocarya caffra, Acacia nigrescens, Combretum apiculatum, Kirkia acuminata, Commiphora* spp., *Acacia* spp., *Terminalia prunioides, Adansonia digitata* and *Grewia* spp. probably form the main constituents over most of the area, but on the soils derived from paragneiss *Kirkia acuminata* appears to be more prevalent, and on the basalt soils *Acacia* spp. and *Combretum* spp. are more abundant, while, as the rainfall diminishes, *Adansonia digitata* and *Commiphora* spp. become more frequent. On shallow basalt/sandstone contact soils *Boscia mossambicensis* and *B. albitrunca* make an appearance and *Sesamothamnus lugardii* is common on the sandstone itself.

The grass cover varies from annual to perennial depending not only on soil type but also on the severity of the grazing pressure to which it has been subjected in the past. On the sandy soils derived from granite and paragneiss *Eragrostis rigidior, E. superba, E. jeffreysii, Heteropogon contortus, Brachiaria nigropedata, Urochloa pullulans, Pogonarthria squarrosa, Digitaria* spp., and *Chloris myriostachya* are common perennials, while on the basalt, *Cenchrus ciliaris, Pennisetum* sp., *Schmidtia bulbosa, Panicum maximum* and *Dichanthium annulatum*, are very common in the western areas and, in the east (Sabi Valley), *Setaria* sp., *Ischaemum brachyatherum, Digitaria milanjiana*, and *Bothriochloa insculpta* are more frequent. Common annuals are *Enneapogon cenchroides, Aristida adscensionis, Dactyloctenium aegyptium, D. giganteum, Eragrostis viscosa, Urochloa* spp., *Tragus berteronianus* and several others.

The following tree/bush types may be recognized:—

1. *Colophospermum - Pterocarpus - Aristida* (Kalahari sand).
2. *Colophospermum - Grewia - Sclerocarya - Kirkia - Eragrostis* (granite, paragneiss).
3. *Colophospermum - Grewia - Acacia - Combretum - Cenchrus* (Basalt).
4. *Colophospermum - Grewia - Commiphora - Aristida* (annual) (several soil types).
5. *Colophospermum - Grewia - Eragrostis.*

D. Bush Savannas. Deciduous unstratified savannas of various types.

(a) *Acacia types.* On clay soils in 20-24 in. rainfall areas bush savannas dominated by one or more species of *Acacia* such as *A. karroo, A. rehmanniana, A. tortilis* subsp. *heteracantha* and *A. nilotica* subsp. *kraussiana* are commonly found. The bushes may be as high as 15 feet and well developed, branching from near the ground, and standing in a well developed grass cover.

This type of vegetation is generally considered to be a seral stage in the secondary succession to a tree savanna dominated by *Combretum apiculatum*, for example, as the species of *Acacia* involved are usually regarded as pioneer species. There are, however, areas where bushes of *Acacia* spp. have remained as the only occupants for some 40-50 years and no other woody species, even in the very young stages, have yet appeared. These other species may, of course, be suppressed by frequent burning and the pioneer *Acacia* stage thus remains as a fire maintained phase in the succession. On the other hand, some of the species of *Acacia* such as *A. gerrardii* and A. *nilotica* subsp. *kraussiana* may represent climax species under these particular climatic and edaphic conditions, and no further changes are likely to take place anyhow. If not burned, cut or cleared these species may develop into trees up to 30-40 ft. high with well-formed boles to form a tree savanna.

The grass cover is predominantly *Heteropogon contortus* in association with *Themeda triandra*, and other species are *Cymbopogon plurinodis*, *Eragrostis* spp., *Bothriochloa insculpta* and *Panicum maximum.*

(b) *Euclea type.* On shallow soils of the Great Dyke at altitudes of 3,500-4,000 feet and a rainfall of 20-24 in., a bush savanna type dominated by *Euclea eylesii* in association with *Diplorhynchus condylocarpon* is often found. *Acacia chariessa* is a common species in this type.

The grass cover is predominantly *Andropogon gayanus* and *Themeda triandra* in association with *Cymbopogon plurinodis*, *Panicum maximum*, *Eragrostis superba*, *Eustachys paspaloides* and others.

(c) *Protea type.* On poor leached granite sands at altitudes of 4,000 ft. and upwards, with a rainfall above 30 in., *Protea gaguedii* and *P. angolensis* with bushy species of *Strychnos* often form a belt of bush savanna round edaphic grasslands resulting from poor drainage.

The grass cover includes species of *Hyparrhenia*, *Chloridion cameronii*, *Schizachyrium* spp., *Digitaria gazensis* and others.

The *Protea* and *Strychnos* plants are often small and poorly developed and the type might then be considered to be a scrub savanna.

E. Bush Clump Savannas

Albizia types. Fairly widely scattered clumps or small groups of bushes and small trees (or with several fairly tall trees in the centre) roughly circular in outline and sometimes found on termite mounds, often form a savanna type at altitudes above 3,500 ft. and a rainfall of 25-30 in. These clumps are largely dominated by *Albizia harveyi* and *Acacia* spp. in association with such species as *Ziziphus mucronata*, *Rhus lancea*, and *Grewia* spp. in a well developed grass cover, containing *Hyparrhenia filipendula*, *H. dissoluta*, *Themeda triandra*, *Heteropogon contortus*, and *Bothriochloa insculpta.*

When the clumps are found on termite mounds these are very often situated in an edaphic grassland of some sort and the trees are present because of the better drainage conditions prevailing on the termitaria. The species are usually different from the above and *Syzygium* is common.

The *Albizia-Acacia* type occurs on well drained red soils and, except for a few cases where the clumps appear to have developed on old hut or kraal sites, it is difficult to see any particular reason for this sort of formation.

F. Bush/Scrub Savanna. These are generally degraded tree or bush savannas resulting from periodic burning and cutting. The scrub constituents are often coppicing trees or bushes, or bushes which have been stunted by fires. They are found under the same conditions as the tree or bush savannas and are generally comprised of *Acacia* spp. often with some of the same species that make up the tree/bush savanna types.

Acacia rehmanniana, A. karroo, A. gerrardii, and *A. nilotica* subsp. *kraussiana* are common species in this bush/scrub type. The grass cover is good and, being on the fertile red soils, is generally dominated by *Heteropogon contortus* and *Themeda triandra.*

G. Scrub Savannas. These may result from the invasion of old lands by woody plants of various species or from frequent fires maintaining a scrub phase in the succession, or by fire, and/or frost, or shallow soils retarding development of the individual trees. The woody plants are generally very short and stunted, up to about 6 ft. high, and sometimes malformed with leaves clustering round very shortened branches. The grass cover varies from poor to well developed.

(a) *Acacia types.* Old cultivated lands particularly on the more fertile soils at various altitudes but usually with a rainfall of 20 in. and more, are often covered by a scrub growth of Acacia such as *A. gerrardii, A. rehmanniana,* or *A. karroo,* and a short grass cover as a result of heavy grazing pressure of a few perennials and a number of annuals. The perennials are generally *Heteropogon contortus* and *Bothriochloa insculpta* and the annuals include *Chloris virgata, Eragrostis patentipilosa,* and *Aristida* spp.

This type is considered to be a seral stage in the succession to a tree savanna of some sort. It is commonly encountered in native areas where stocking rates are heavy and fires have little effect on bush encroachment on account of the lack of inflammable material. The *Acacia* plants are small but not malformed in any way and merely represent a young stage of growth.

Where the grass cover is better and periodic fires occur, the Acacia bushes are actually stunted, fire-scarred and malformed.

(b) *Smithia type.* In the high rainfall areas of the Eastern Border the woody shrubs *Smithia thymodora** and *Psoralea foliosa* associated with bracken *(Pteridium aquilinum)* and a number of other smaller woody and herbaceous species cover extensive areas with a scrub savanna type of vegetation. The grass cover contains such species as *Hyparrhenia cymbaria, Cymbopogon validus* and *Setaria splendida.* This type is probably a seral stage in the succession to Dry Montane Forest, as fires play an important part in maintaining the scrub condition. Protection from fire encourages the woody species.

(c) *Colophospermum types.* Three types of *Colophospermum mopane* scrub-savanna are found, viz.:

(1) that occurring on deep cracking heavy clays on basalts and Madumabisa shales (see Vincent & Thomas (7) sections 162 and 187);

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* This species should be transferred on systematic grounds to the genus *Kotschya* Endl. but this has not yet been done by the systematists and this is not a suitable article in which to effect such a transference. For the time being therefore, we will refer to a *Smithia type* although it will eventually no doubt be referred to as a *Kotschya type.*

(2) that occurring on shallow stony basalt soils;

(3) that on low-lying drainage areas subject to severe frosts; and

(4) that which has developed as a result of coppicing.

This latter type may often develop into a bush/scrub type of savanna. Small stunted *Colophospermum* trees or bushes are also found on soils with a strongly alkaline compacted sub-soil, known in Matabeleland as "sikwakwa" soils. Because of the complete, or almost complete, lack of grass, it is often considered that such areas should not be included in a savanna type of vegetation as the term savanna implies that a good grass cover is present. As these areas are usually small in relation to the broad type of vagetation in which they occur there seems to be no necessity to classify them separately.

On the shallow basalt soils the grass cover is generally very sparse and consists largely of annuals such as *Enneapogon cenchroides, Aristida* spp., and *Eragrostis viscosa* with a few scattered perennials like *Schmidtia bulbosa, Pennisetum* sp., and *Cenchrus ciliaris.*

4. BUSHLANDS OR THICKETS

Mostly deciduous bushlands and thickets of woody species up to 15-20 feet high, which are usually secondary, developing on old lands which have had a certain amount of protection from fire.

(a) *Combretum types.* In the hot Zambezi Valley with a low effective rainfall, on deep sandy soils, *Combretum eleagnoides* and *C. celastroides* together with *Schrebera trichoclada, Acacia mellifera* subsp. *detinens, Terminalia* sp., *Commiphora* spp., and a number of others form a dense impenetrable thicket. These are particularly common between the northern escarpment and the Zambezi itself. They appear to have developed as a result of previous cultivations. The local name for these thickets is "Jesse" bush. The grass cover is absent except for a few annuals.

(b) *Dichrostachys types.* At various altitudes and rainfalls and usually on alluvial or other fertile soils, dense thickets of *Dichrostachys cinerea* subsp. *cinerea* are often found, mostly pure, but sometimes associated with species of *Acacia.* The grass cover is absent or consists of a few annuals.

These have all developed on old cultivations and constitute one of the most serious bush encroachment problems in Matabeleland.

(c) *Acacia types.* At various altitudes and rainfalls and usually on alluvial or other fertile soils thickets of various species of *Acacia* often develop on old fallows and other disturbed areas. *Acacia tortilis* subsp. *heteracantha, Acacia mellifera* subsp. *detinens,* and *Acacia ataxacantha* are some of the common species forming thickets but other species may also become very dense when protected from fire, and then represent more of a bushland than a thicket. The grass cover is absent or very sparse and consists of a few annuals.

(d) *Philippia type*. Under the high rainfall-high altitude conditions of the Eastern Districts, *Philippia benguelensis* and *Smilax kraussiana* often form dense thickets.

(e) *Smithia types*. When the *Smithia-Psoralea* scrub savanna on the Eastern Districts is protected from fire a dense thicket of *Smithia thymodora* (see footnote p. 88) may develop.

(f) *Androstachys type*. In the southern lowveld with a rainfall of less than 16 in. annually, *Androstachys johnsonii* often forms pure thickets on sandstone sites, or is associated with species of *Combretum, Croton, Phyllanthus, Vitex* and others. Sometimes, however, in the Nuanetsi District (and in P.E.A.) *Androstachys* reaches its climax of development and may form very dense woodlands or deciduous forest in ravines and along steep stream banks.

(g) *Other secondary thickets*. In this category fall a number of secondary thickets which have developed as a result of dense coppicing. These are usually found in areas where mining activities have been extensive and carried on for a long time. Here all the trees for some considerable distance round the mines themselves have been periodically cut over for fuel or poles, and in many cases a dense thicket of coppice growth has resulted. This is particularly the case where *Brachystegia* spp., *Julbernardia globiflora* and *Colophospermum* types of woodland and savanna have been involved.

5. GRASSLANDS

(It should be noted that there are distinct seasonal changes in aspect in the grass cover, but those grasses that are visually dominant in the late summer phase have generally been used as the characterizing species.)

A. Biotic or Secondary Grasslands. (Generally considered by many ecologists to be derived from forest or woodland and maintained by fire. In certain areas, however, it is possible that these grasslands may be considered as transitional to High Montane Climax Grasslands.)

(a) *Themeda or Loudetia types*. Short, dense, tufted grasslands dominated by *Themeda* on the more fertile red soils or *Loudetia* on the poorer granite sands. Occurring at high altitudes and under high rainfall conditions in the mountains of the Eastern Districts. Regarded as a fire sub-climax to forest, relicts of which occur in patches in sheltered or fire-protected localities. Common associated grasses are *Andropogon schirensis, Bewsia biflora, Eragrostis racemosa, Elyonurus argenteus, Tristachya hispida* and *Setaria* sp. Often invaded by bracken, *Philippia, Smithia* and other shrubs when protected from fire.

(b) *Hyparrhenia types.* Tall dense grasslands dominated by *Hyparrhenia filipendula* or *H. dissoluta.* Occurring on the plateaux of the main watershed on granite sand, particularly between Salisbury and Rusape at altitudes above 4,500 ft. Regarded as a fire sub-climax to woodland.

Common associated grasses are *Andropogon* spp., *Chloridion cameronii,* and *Eragrostis* spp.

Often surrounding, and merging with, edaphic grasslands, resulting from shallow soils subject to varying periods of waterlogging, and dominated by *Loudetia simplex* or *Schizachyrium* spp.

B. Edaphic Grasslands. (Largely resulting from waterlogging or shallowness of soil.)

(a) *Andropogon gayanus type.* Tall tufted grassland dominated by *Andropogon gayanus* occurring on the shallow soils of the Great Dyke which are largely derived from norite and pyroxenite and are high in magnesium. Common associated grasses are *Themeda triandra* and *Panicum maximum. Themeda* is often co-dominant.

(b) *Loudetia types.* A number of edaphic grasslands or "vleis" occur at altitudes above 3,500 ft. on shallow soils generally derived from granite and subject to varying periods of waterlogging and which are dominated by *Loudetia simplex* or *L. flavida* alone or in association with each other or with a number of other species. The *Loudetia* species themselves are usually found on the drier fringes, and, depending on the degree of wetness and length of the period of waterlogging (whether very temporary or permanent) may be associated in varying combinations with such species as *Monocymbium ceresiiforme, Schizachyrium* spp., *Brachiaria filifolia, Eragrostis capensis, Aristida macilenta, Sporobolus subtilis, Andropogon eucomus, Scleria welwitschii, S. griegifolia,* and *Eriocaulon lacteum.*

(c) *Acroceras type.* A low-growing swamp type occurring on heavy black clays or on granite sands in shallow pans that often contain standing water for part of the year and characterized by almost pure communities of *Acroceras macrum.* Found largely at altitudes above 4,000 ft. and where rainfall is over 30 in. annually.

(d) *Echinochloa types.* Occurring on alluvial soils in pans in the lowveld at altitudes below 2,500 ft., particularly the Sabi Valley, where *Echinochloa* sp. (near *E. holubii)* is predominant and may be associated with *Eragrostis rotifer, E. aethiopica, Diplachne fusca* and *Leptochloa* sp. in the mopane areas, and with *Bothriochloa glabra* and *Panicum coloratum* in the *Acacia* savanna.

(e) *Alloteropsis types.*

(1) Short to medium, tufted grassland occurring on damp soils derived from fertile red clays at altitudes above 4,000 ft. *Alloteropsis semialata* is predominant and generally associated with a *Setaria* sp.

(2) Short to medium, tufted, but somewhat sparse, grassland, occurring on Kalahari sands which are subject to waterlogging for a greater part of the rainy season and where the rainfall is above 30 in. annually. *Alloteropsis semialata* is generally dominant and associated with *Tristachya hispida,* or *Eragrostis hispida* (such as at Felixburg).

(f) *Setaria types.*

(1) Medium to tall well developed grassland on heavy black, cracking, self-ploughing, clays, subject to temporary waterlogging and derived from basalt or epidiorite at all altitudes. *Setaria porphyrantha* is predominant and almost invariably associated with *Ischaemum brachyatherum, Dichanthium papillosum, Brachiaria eruciformis* and sometimes *Sorghum versicolor.*

(2) Tall well developed grassland usually on heavy black soils derived from basement schists at altitudes between 3,500 ft. and 5,000 ft. and dominated by *Setaria sphacelata.* Sometimes associated with *Hemarthria fasciculata, Themeda triandra* or *Eragrostis* sp.

(g) *Imperata type.* A low growing grassland type on black fertile soils which remain moist for the greater part of the year, at all altitudes. Dominated by a close sward of *Imperata cylindrica.* On basaltic soils often associated with *Miscanthidium* sp., *Bothriochloa glabra* and *Setaria* sp.

(h) *Pennisetum types.* A tall dense grassland on permanently moist or wet granite sands, dominated by pure colonies of *Pennisetum glaucocladum,* or by *P. polystachyon* on the more fertile black clays; mostly in the warmer parts below 4,500 ft.

(i) *Hyparrhenia types.* In those parts of the country above 3,500 ft. where the rainfall is below 25 in. annually, *Hyparrhenia filipendula* and *H. dissoluta* often form dense grasslands where additional soil moisture is available as a result of run-off from nearby granite outcrops, or where road culverts spill large quantities of storm water, or where drainage is poor.

(j) *Themeda type.* Small grasslands of *Themeda triandra* often occur where soils derived from dolerite become temporarily waterlogged.

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VEGETATION MAP OF THE FEDERATION OF RHODESIA AND NYASALAND

(for map see end cover pocket)

by

J. M. RATTRAY & H. WILD

The *raison d'être* for the production of this map was, in the first place, that it was required to form part of the Federal Atlas series now being produced by the Director of Federal Surveys. It is in fact Federal Atlas Map No. 10. However, once the decision was taken to prepare such a map, in spite of the gaps in our detailed knowledge of the vegetation of the Federation that still exist, it was thought desirable to take the opportunity to use a system of classification of the vegetation that followed as closely as possible the recommendations of the C.S.A. (Scientific Council for Africa South of the Sahara) Specialist Meeting held at Yangambi in 1956, a process already begun for the Federation in a descriptive manner, though not in the form of a map, by Boughey (1957). There has been considerable disagreement, on the part of some botanists and phytogeographers, with these recommendations in the past and there still remains a certain amount of criticism. They do, however, offer the only possibility of agreement along broad lines by botanists of the many nationalities at present working on the vegetation of Africa. The Vegetation Map of Africa produced by Keay (1959) has also been consulted, particularly in relation to the nomenclature of vegetation types. Keay was also, of course, trying to apply the Yangambi recommendations as closely as possible. In the case of the grasslands the first author of this paper naturally drew on the experience gained in the production of his "Map of the Grass Cover of Africa" (Rattray, 1960).

As far as the outlines of the vegetation types is concerned, the map is to a considerable extent a compilation based on the published maps of Henkel (1931) for Rhodesia, Trapnell, Martin and Allen (1950) for Northern Rhodesia and unpublished maps of R. G. M. Willan and G. Jackson for Nyasaland. Some modifications were made to the Northern Rhodesian part of the map, however, with the welcome assistance of D. B. Fanshawe and to the Southern Rhodesia map by a number of able authorities in this field. In particular the following were able to produce field sketch maps of particular areas and offer detailed criticisms:—

B. Goldsmith—map of Zambezi Valley (Sebungwe with detailed outlines of *Brachystegia boehmii* and *B. spiciformis* woodlands.

D. F. Lovemore—map of Zambezi Valley (Urungwe).

J. B. Phipps—sketch map of Lower Shire Valley.

J. G. Thompson—outlines of thicket formations in Zambezi Valley.

V. Vincent—outlines of *Baikiaea plurijuga* woodlands in the Wankie District.

In addition we would like to acknowledge the assistance provided by the Forestry Commission of Southern Rhodesia in making available large numbers of vegetation maps compiled over many years by members of its staff and former members of its predecessor, the Forestry Department of the Southern Rhodesia Government.

The various colours used reflect the change from the wettest to the driest areas by passing from the violet end of the spectrum for the montane and submontane grasslands with forest patches to the red end of the spectrum for the dry mopane woodlands or savannas.

In addition to the colour variations a system of hatching or scoring has been incorporated so that it is possible to recognize at once with which broad physiognomic classification we are dealing:—

solid colours—moist evergreen, moist montane or dry montane forest, or grassland
narrowly spaced horizontal lines—deciduous or dry evergreen forest
cross hatching—thicket
narrowly spaced vertical lines—woodland
broadly spaced vertical lines—savanna.

It was originally hoped by the authors that these scorings could be carried out in inked lines superimposed on solid colours as in the Map of the Grass Cover of Africa (Rattray, 1960), but this system could not, unfortunately, be used in this instance and this has made the separation by eye of two of the colours in the savanna categories rather difficult (22. *Burkea africana—Dialium engleranum—Baikiaea—Colophospermum* from 24. *Acacia*).

In the attempt to follow the Yangambi recommendations, some difficulties have been encountered. Sometimes they are problems which are more or less specific to the Federation and some are of a more general nature. These will be dealt with under the individual categories concerned.

GRASSLANDS

1. Themeda/ or Loudetia/ or Exotheca and Evergreen Forest (Widringtonia, Podocarpus, Khaya, Hagenia, etc., patches)

(a) *Evergreen Forest*

When these forest patches reach sufficient size for individual mapping they are represented in solid black (category 6, which see below) but frequently they exist as small relic patches or as a fringe along mountain streams and rivers and may be as small as an acre or so in area. They are in a state of rather delicate equilibrium with the surrounding grasslands and can be only too readily destroyed by fire or cultivation. They occur throughout the higher rainfall grasslands in Nyasaland and the Eastern Border of Southern Rhodesia (Inyanga, Vumba, Melsetter and Chipinga Districts). They occur in Northern Rhodesia where the Nyika plateau crosses the border from Nyasaland for a short distance.

(b) *Themeda* or *Loudetia* or *Exotheca* grassland with evergreen forest patches

In Nyasaland, Jackson (1954) divides the grasslands into High Montane, Montane and Slope Grasslands. The High Montane type is a short heathy grassland with a low ground cover and is dominated by *Loudetia simplex, Trachypogon spicatus forma, Exotheca abyssinica* and *Festuca abyssinica* with *Rendlia altera* in the spring phase. The Montane Grasslands are short to medium, tufted and of low percentage ground cover and are probably, at least partially, derived from evergreen forest. According to soil, site, aspect and, more particularly, the time that has elapsed since the destruction of the forest, there are several phases dominated by *Loudetia simplex - Monocymbium ceresiiforme*, or *Themeda triandra-Exotheca abyssinica* or *Hyparrhenia cymbaria-Setaria longiseta*, or *Andropogon schirensis - Elyonurus argenteus* or a few other species. The Slope Grasslands are dominated by such species as *Themeda triandra, Exotheca abyssinica, Melinis* spp., and *Rhynchelytrum* spp. often associated with *Protea* spp. and *Pteridium aquilinum.*

In Southern Rhodesia and Nyasaland short dense tufted grasslands dominated by *Themeda triandra* on the more fertile red soils, or *Loudetia simplex* on the poorer granite sands, occur at high altitudes and under high rainfall conditions in the Eastern Districts, regarded as a fire sub-climax to evergreen forest, relics of which occur in patches in sheltered fire-protected localities. Common associated species are *Andropogon schirensis, Bewsia biflora, Eragrostis racemosa, Elyonurus argenteus, Tristachya hispida* and *Setaria* sp. often invaded by bracken *(Pteridium aquilinum), Philippia, Kotschya* and other shrubs when protected from fire.

2. Hyparrhenia Grassland

In Southern Rhodesia *Hyparrhenia* grassland is found at altitudes above 3,500 ft. either on the sites of ancient clearings or because of some factor resulting in extra soil moisture. *H. filipendula* and *H. dissoluta* are the common species, associated with *Chloridion cameronii, Schizachyrium* sp. and *Andropogon* sp. In Northern Rhodesia, according to Trapnell, *Hyparrhenia* grasslands are found on certain watersheds as well as in some of the valleys and flood-plains. *Hyparrhenia rufa* and *Setaria* sp. edaphic grasslands predominate on the Kafue Flats and on other clayey flood-plains.

3. Loudetia Grassland

In Southern Rhodesia, *Loudetia* grasslands dominated by *L. simplex* or *L. flavida* alone or in combination occur at altitudes above 3,500 ft., on shallow soils generally derived from granite and subject to varying periods of waterlogging. The *Loudetia* species are usually found on the drier fringes and, depending on the degree of wetness and length of the period of waterlogging, are associated in varying combinations with *Monocymbium ceresiiforme, Schizachyrium spp., Brachiaria filifolia, Eragrostis capensis, Aristida macilenta, Sporobolus subtilis, Andropogon eucomus, Scleria spp.,* and *Eriocaulon lacteum.*

According to Trapnell (1950), in Northern Rhodesia the great watershed Kalahari Sand plains of Barotseland carry a grassland of *Loudetia simplex* and similar wiry species which are replaced by a *Tristachya* in the Siluana Plains. The smaller and wetter plains of central Barotseland often contain a *Miscanthidium* type and both *Loudetia* and *Hyparrhenia* types are found on the Kalomo watershed grasslands. *Loudetia simplex* and similar types also occupy some valley grasslands and large areas of the flood-plains of the Chambezi-Bangweulu basin.

4. Andropogon Grassland

Tufted grasslands of *Andropogon gayanus* or *A. schirensis* sometimes with *Loudetia simplex* occur in Southern Rhodesia on the shallow soils of the Great Dyke which are largely derived from norite and pyroxenite and are high in magnesium and chrome. *Themeda triandra* is often co-dominant or locally dominant, and *Panicum maximum* is another common species at least in the southern half of the Dyke.

5. Swamp and Papyrus Sudd

These areas are merely the more or less permanently flooded portions of the *Hyparrhenia* grassland (2) in Northern Rhodesia, the flood plain of the Shire River and the marginal areas of Lakes Malombe and Chilwa in Nyasaland, with another small area near Nkata Bay. In some cases sudd forming species such as *Cyperus papyrus, Vossia cuspidata, Scirpus cubensis, Ludwigia* spp. are important as in Lake Bangweulu. Aquatics such as *Nymphaea* spp., *Nymphoides indica, Pistia stratiotes, Ottelia* spp. are of course important in open water. Aquatic and subaquatic grasses such as *Echinochloa pyramidalis, Pennisetum purpureum, Miscanthidium teretifolium, Eleocharis plantaginea* and *Echinochloa stagnina* are common (see Jackson, 1954, and Trapnell, 1950).

6. Moist Evergreen, Moist Montane and Dry Montane Forest

Of sufficient size to map on our scale only in Nyasaland, but exists also on the Eastern Border of Rhodesia (see category 1).

(i) *Moist Evergreen Forest*

The best example in Southern Rhodesia is Chirinda Forest in the Chipinga District. *Khaya nyasica, Lovoa swynnertonii, Diospyros abyssinica* and *Craibia brevicaudata* are representative species. As its altitude is about 3,500 ft., it shows some transition towards moist montane forest with such species as *Macaranga mellifera* and *Polyscias malosana*. In Northern Rhodesia moist evergreen forest can scarcely be said to occur, but can be found in Kota Kota and Nkata Bay District of Nyasaland as relics (Jackson, 1954). Brass (1953, p. 185) refers to relics of this type in the Chibotela District containing *Garcinia huillensis, Trichilia emetica* and *Bequaertiodendron magalismontanum*. A particularly interesting example is found on the Malawi and nearby hills which rise to about 3,000 ft. in the Shire Valley in the Port Herald District. Typical trees are *Khaya nyasica, Fernandia magnifica, Olea welwitschii* and *Burttdavya nyasica*.

(ii) *Moist Montane Forest*

Well represented on the Eastern Border of Rhodesia and in Nyasaland, but once again usually in small patches. Typical species are *Macaranga mellifera, Rapanea melanophloeos, Albizia gummifera, Ilex capensis, Trimeria rotundifolia, Pittosporum viridiflorum* and *Dovyalis lucida*.

In Nyasaland, Brass (1953) quotes such species as *Hagenia abyssinica, Kiggelaria africana, Pygeum africanum, Rapanea melanophloeos*, etc.

(iii) *Dry Montane Forest*

Best represented in Nyasaland on Mlanje Mt., Vipya Mt. and the Nyika. The most characteristic species is *Widdringtonia whytei*, for an extended account of which see Chapman (1961). *Podocarpus milanjianus* is also important here. *Juniperus procera* is dominant on some parts of the Nyika. *Podocarpus milanjianus* and *Widdringtonia whytei* are sufficiently well developed to constitute this forest type in Southern Rhodesia only in Banti and nearby forests south of Umtali.

DECIDUOUS OR DRY EVERGREEN FORESTS

7. Baikiaea plurijuga Deciduous Forest

Confined to the Kalahari sand areas of Northern Rhodesia (but see 15. Baikiaea woodland in S. Rhodesia below). Although growing in a low rainfall area (20 in. per annum) may be considered true forest since the grass cover is almost absent, the canopy is continuous and there is fairly dense understorey of *Combretum, Acacia* and *Commiphora* spp. (Trapnell, 1950).

8. Cryptosepalum Dry Evergreen Forest

Restricted to the Kalahari sands of Northern Rhodesia and small areas near Lake Bangweulu. *Cryptosepalum pseudotaxus* is the dominant species with lianes such as *Combretum microphyllum, Uvaria angolensis, Artabotrys monteiroae*, etc. Grasses are of a forest type and sparse. There may also be a dense understorey of *Diospyros undabunda* evergreen thicket with lianes (Fanshawe, 1961).

Also according to Fanshawe (1961) there is another type of dry evergreen forest in Northern Rhodesia. It is not large enough to map here but consists of *Parinari exelsa* and *Syzygium guineense* as dominants in small patches near Ndola.

THICKETS

9. Bussea-Combretum Thicket

Covers large areas around Mweru-wa-Ntipa. Consists of impenetrable thicket belts of *Bussea massaiensis, Combretum tetrandrum* and *Pseudoprosopis fischeri* (Trapnell, 1950), with a thin ground cover of annual shade-loving panicoid grasses.

10. Commiphora-Combretum-Pterocarpus antunesii Thicket

The "Jesse" thicket of the Zambezi Valley. It occupies parts of the alluvial plain of the Zambezi near Chirundu, but also runs along the foot of the southern escarpment and along the tributaries of the Zambezi to the east. Contains many *Commiphora* spp., *Pteleopsis, Combretum tetrandrum, Stereospermum kunthianum* and much *Dichrostachys cinerea.*

WOODLANDS

11. Brachystegia Woodland often with Julbernardia globiflora or J. paniculata

In Southern Rhodesia the Brachystegia is *B. spiciformis* and the *Julbernardia* always *J. globiflora.* The trees are from 20-40 ft. tall and the understorey of shrubs and smaller trees not as a rule very dense. In Northern Rhodesia and Nyasaland *J. paniculata* often replaces *J. globiflora*, although the latter still predominates in the western and southern parts of Northern Rhodesia. The trees are also noticeably taller as a rule. Trapnell, Martin and Allen (1950) mapped some seven different types of *Brachystegia* woodland according to which species of *Julbernardia* was present and which *Brachystegia* species, but this has not been found possible on our scale. *Brachystegia floribunda, B. longifolia, B. spiciformis* and *B. wangermeeana* are the common species of the northern woodlands, whilst *B. burtii* is important in the eastern woodlands. In Nyasaland *Brachystegia manga, B. stipulata* and *B. floribunda* also assume importance. Near Nkata Bay a small area of *B. spiciformis* becomes mixed with evergreen species and gives a type of evergreen forest. This is very similar to the *Brachystegia spiciformis* "forest" seen by the second author of this article on the inland dunes near the coast of Mozambique south of Inhambane. Grass cover is almost absent and lianes and evergreen thicket are fairly well developed. On the Copperbelt, with its moderately high rainfall approaching 60 in. per annum, *Brachystegia spiciformis* woodland after relatively few years of fire protection begins to develop deciduous or dry forest characteristics. Even when forest characteristics are not developed in the north-western parts of Northern Rhodesia, the *Brachystegia* woodland is much better developed with understorey layers than in Southern Rhodesia and trees attain heights of up to 100 ft. The same is true in Nyasaland also.

12. Brachystegia Escarpment Woodlands

Composed generally of *B. boehmii* woodland in Southern Rhodesia and lies between 3,000 ft. and 4,000 ft. On both escarpments of the Zambezi and Luangwa Rivers, however, *B. allenii* becomes important and frequently produces hybrid populations with *B. boehmii.* Although this formation does occur on the escarpment of Lake Nyasa, it is so intimately mixed with category 13 (see below) that we have not been able to map it separately.

13. Pterocarpus Woodland with Oxytenanthera Thicket

Confined to the escarpments of Lake Nyasa and the Shire Valley. Consists typically of *Pterocarpus angolenisis* woodland with a thicket of *Oxytenanthera abyssinica* beneath it (Jackson, 1954, p. 7).

It frequently passes into *Brachystegia* escarpment woodlands in which the principle tree species are *B. boehmii, B. allenii, B. manga, B. bussei* and *Uapaca kirkiana.*

14. Marquesia Woodland

Confined to the Western and Northern Provinces of Northern Rhodesia and does not occupy very extensive areas. The dominant species, *M. acuminata,* is evergreen although often mixed with deciduous *Brachystegia spiciformis* or *B. longifolia.* It therefore approaches a dry forest type. Another species of *Marquesia (M. acuminata)* is the dominant species of small patches of dry forest on the Copperbelt (Fanshawe, 1961), but these are too small to map on this scale.

15. Baikiaea Woodland

Confined to Southern Rhodesia. Does not differ radically from the deciduous *Baikiaea* forest of Northern Rhodesia, but perhaps because of more frequent fires, heavier game populations in the past, or less readily available water supplies, the *Baikiaea* is less well grown, more open and with a poorer development of understorey species than in Northern Rhodesia. Considered solely on a physiognomic basis, therefore, it must be differentiated from the Northern Rhodesian forest and be designated a woodland. As in Northern Rhodesia it is confined to Kalahari Sand.

16. Colophospermum mopane Woodland

Confined to the valleys of the Zambezi and its tributaries, the valley of the Luangwa and the Shire Valley. On the whole much better developed, as far as tree size and density is concerned, than that of the Sabi and Limpopo systems (see 26 below). Although very deciduous, the canopies of the mopane in the more northern parts of our area do touch and so we have a true woodland. Often occurs in pure stands but may be mixed with *Kirkia acuminata, Sterculia africana, Commiphora* spp., *Combretum* spp., etc. Near pans or when merging with *Adansonia-Cordyla-Sterculia-Acacia* savannas is liable to become a savanna-woodland. With varying soil conditions, mopane density often varies considerably over short distances and the savanna or woodland classification becomes very difficult to apply.

17. Combretum-Acacia-Piliostigma-Terminalia Woodland

Confined to the Lilongwe and Palombe River areas of Nyasaland. However, it is very closely related to a savanna formation found at the margins of the Kafue Flats. The difference lies merely in its density. According to Jackson (1954, p. 4) this formation is often an indication of deep fertile soils.

SAVANNAS

18. Pterocarpus-Erythrophleum Savanna

Confined to Northern Rhodesia and very extensive in the region of Lake Bangweulu. Also occurs in the Luapula Valley towards Lake Mweru and north-east of Mwinilunga. This is the "Chipya" of Northern Rhodesia. The dominant species are *Pterocarpus angolensis, Erthrophleum africanum* and *Parinari curatellifolia*. The grasses are tall savanna types and where *Syzygium* belts become important the formation approaches evergreen forest. Areas too small to map here also occur in the Copperbelt.

19. Diplorhynchus Shrub Savanna

The "Diplorhynchus and other scrub grasslands" of Trapnell (1950, p. 14). Consists of various mixtures of *Diplorhynchus condylocarpon, Hymenocardia, Uapaca, Protea, Combretum,* etc., scattered through short grasslands. It occupies great expanses of the watershed plains of Barotseland.

20. Parinari Savanna

Confined to two rather narrow belts running north and north-west of Salisbury. This formation may have been artificially induced by the cutting out of accompanying species such as *Brachystegia spiciformis* and *Julbernardia globiflora*, i.e., it is perhaps a degraded woodland, but sometimes, at least when occurring on sandveld soils subject to waterlogging, it is probably a true savanna of edaphic origin. The species concerned, *Parinari curatellifolia*, is widespread and common in the Federation except at low altitudes but does not usually predominate over large areas. It is also rather important but not capable of being mapped here in savannas of the Chipinga District near Chirinda Forest.

21. Combretum-Afrormosia-Pterocarpus-Acacia Savanna

Related to the denser mixed woodland of the Lilongwe district but here giving a savanna formation surrounding the grasslands of the

Kafue Flats and another smaller area in the neighbourhood of Petauke. The Acacia species involved are usually *A. sieberiana, A. albida, A. polyacantha* and *A. tortilis* subsp. *heteracantha.* The *Combretum* species sometimes become predominant and form a type of bush savanna, whilst in areas where the Acacia species assume less importance, the predominant taller trees are often *Pterocarpus angolensis, P. rotundifolius* or *Ostryoderris stuhlmannii.*

22. Burkea africana - Dialium engleranum - Baikiaea - Colophospermum Savanna

Can be subdivided into *Burkea-Colophospermum-Baikiaea* types in south Barotseland, with admixtures of *Pterocarpus angolensis, Brachystegia spiciformis-Burkea africana* savannas in the Namwala District in which *Erythrophleum africanum* and *Pterocarpus angolensis* often occur, and *Dialium engleranum* savannas with *Burkea africana* admixtures in the Sesheke area (Trapnell, 1950).

23. Terminalia Savanna

Only of importance as a distinct unit in the Bulawayo area of Southern Rhodesia. The species concerned is *T. sericea,* which occurs throughout the Federation at low and medium elevations and can from time to time be important locally within many other formations such as *Colophospermum* woodland and savanna, *Acacia* savanna and *Brachystegia* woodland.

24. Acacia Savanna

Mappable on our scale only in Matabeleland and in a small area near Beatrice. The species concerned are *Acacia nilotica* subsp. *kraussiana, A. karroo* and *A. rehmanniana* often mixed with *Albizia harveyi, Bolusanthus speciosus, Rhus lancea, Peltophorum africanum, Sclerocarya caffra,* etc. (Henkel, 1931).

This is the formation which Keay (1959) mapped as "Wooded steppe with abundant *Acacia* and *Commiphora*". The present authors are in agreement with Boughey (1957, p. 84) here that true steppe does not occur in the Federation. If the *Colophospermum, Terminalia, Combretum - Afrormosia - Pterocarpus - Acacia, Burkea - Dialium - Baikiaea - Colophospermum* and *Adansonia - Hyphaene - Acacia - Sterculia - Cordyla* formations are savannas then so is the *Acacia* formation. They all form one broad physiognomic unit. It may be that here we are faced with a difficulty in the application of the Yangambi classification. Savanna is described therein (1956) as "Formations of grasses at least 80 cm. high, forming a continuous layer dominating a lower stratum. Usually burnt annually. Leaves of grasses flat, basal and cauline. Woody plants usually present.", and Steppe as "Open herbaceous vegetation, sometimes also with woody plants. Usually not burnt. Perennial grasses usually less than 80 cm. high, widely spaced. Leaves of grasses narrow, rolled or folded, mainly basal. Annual plants very often abundant between the perennials". The distinctions here are not very good and particularly in the case of the heights of the grasses and their leaf-form very difficult to apply. The difficulty is even more marked in much of Bechuanaland Protectorate, where one would classify the Kalahari Desert, for instance, as savanna in a good season and steppe in a bad because of the variation in grass development and the activity of game. In this region the boundary between savanna and steppe would be very much a matter of opinion.

In the Wankie District *Acacia giraffae* and *A. uncinata* become important. Although it has not been possible to map it separately, *Acacia tortilis* subsp. *heteracantha* becomes important in parts of the *Colophospermum* savannas of the Sabi Valley. *Acacia xanthophloea* savannas are important in flood plains of the Limpopo Valley and various combinations of *Acacia polyacantha* subsp. *campylacantha, A. sieberiana, A. albida, A. tortilis, A. nigrescens* and *A. giraffae* become important in the Sesheke District, the Zambezi, Luangwa and Shire Valleys, as well as in the Lake Plain of Nyasaland (see Trapnell, 1950, and Jackson, 1954). These occurrences are, however, so intermingled with surrounding savannas of various types that they are not capable of separate representation on this scale.

25. Adansonia-Hyphaene-Acacia-Sterculia-Cordyla Savanna

Mapped as a distinct unit only in the Shire Valley and the Lake Plain of Nyasaland, but with more accurate surveys or the use of larger scales it will eventually be possible to map this formation in the Luangwa, Zambezi, Sabi and Limpopo Valleys. The species principally concerned are *Adansonia digitata, Hyphaene ventricosa, Sterculia africana* and *Cordyla africana*. The *Hyphaene* savannas and *Cordyla africana* savannas are confined to river valley flood plains and probably indicate readily available soil water.

26. Colophospermum mopane Savanna

Confined to the Sabi and Limpopo Valleys as mapped here but, as with the *Colophospermum* woodlands to the north which often open out into savannas, these southern mopane formations may now and then do the reverse and thicken up into woodlands or savanna-woodlands. The distinction is not always clear cut. Individual specimens are often not more than 25-30 ft. in height but on alluvial soils, where there is a tendency towards woodland development, heights may reach 60 ft. As indicated under 24 and 25 above, large scale mapping and more accurate surveys will allow us to eventually subdivide this category into *Colophospermum, Acacia, Adansonia,* etc., savannas. In a descriptive form this area will be dealt with much more comprehensively by the first author of this paper in an article on the types of vegetation in Southern Rhodesia (Rattray, 1961).

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THE BRANCHING OF *TRICERATELLA:* A CORRECTION

by

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In the description and discussion of the recently described genus of Commelinaceae, *Triceratella* (Brenan in Kirkia 1: 14-19 (1961)), the position of the inflorescences was said to be axillary. This is incorrect: they are in fact leaf-opposed.

The more or less elongate cincinni terminate stalks which arise from the very short erect main stem, along which the nodes are very close together and the internodes correspondingly short. The actual insertions of the stalks bearing the inflorescences are concealed by the sheathing leaf-bases. Close inspection shows that each stalk arises from the stem on the side away from that of its subtending leaf. Usually, at least, the stalk bears not only a cincinnus but also, below it, a single leaf similar to those on the main stem. Normally the axillary bud of this single leaf does not develop, but occasionally it does, and then it forms a secondary main stem exactly similar morphologically to the primary main stem. Each cincinnus is thus also leaf-opposed in relation to the leaf on its own stalk. Although it might be maintained that only that part of the stalk above the leaf is the true peduncle, morphologically they are certainly part of the same axis. Each cincinnus terminates an axis which arises in the axil of a leaf, forms one internode of the main stem and then diverges as the peduncle of the cincinnus usually bearing a leaf. Morphologically then, the axis changes at each node of the main stem, which is thus a sympodium. This arrangement extends, of course, to the cincinnus itself. Each flower is itself leaf-opposed to its subtending bracteole and the inflorescence is likewise sympodial, as it is generally in the family.

A sympodial way of growth is said to be characteristic of Brückner's "dorsiventral growth-type" (Engl., Bot. Jahrb. 61: Beibl. 137: 28 (1926)), although the general habit of *Triceratella* is anything but typical of this group, into which Brückner places almost all species of *Commelina*, and a large part of *Aneilema*, *Tradescantia* and *Zebrina*. It is evident, however, that Brückner is using the term "sympodial" in a rather loose way here, perhaps to indicate a lack of any clearly defined main axis, since only in *Commelina* of the four genera mentioned does truly sympodial branching regularly occur.

When I originally described *Triceratella*, I compared it with *Buforrestia*, *Stanfieldiella*, *Pyrrheima*, *Dichorisandra*, *Tinantia*, *Tradescantia*, and *Thyrsanthemum*. All these genera, as far as can be seen, have terminal or sometimes axillary inflorescences, and monopodial growth of the main stem. The sympodial growth of *Triceratella* emphasizes its isolated systematic position, and reinforces its distinctness as a genus. Although sympodial growth occurs elsewhere in *Commelinaceae* I can think of no other instance of the regularity and uniformity with which it occurs in the main stem of *Triceratella*, although near approaches are to be seen in *Athyrocarpus* and some species of *Commelina*. In this feature then, *Triceratella* is relatively more specialized and advanced than most of the remainder of its family. Its actinomorphic flowers, on the other hand, with their regular petals and complete undifferentiated androecium, seem relatively less specialized and advanced than those of genera such as *Aneilema* and *Commelina*.

I am indebted to my colleague Mr. L. L. Forman for much help and stimulating discussion during the writing of this note.

A STATISTICAL ANALYSIS OF A SAMPLE OF THE *FLORA ZAMBESIACA*

by

A. W. Exell & H. Wild

Resulting from the work done for *Flora Zambesiaca*, Vol. **I**, we have available a sample of 618 specific and infra-specific taxa from the *Flora Zambesiaca* area (Bechuanaland Prot., the Rhodesias, Nyasaland and Mozambique, but omitting the Caprivi Strip which is of no consequence for this investigation) as accurately named as can be hoped for under present conditions and with their distribution outside the area fairly well indicated. We cannot resist the temptation to make a statistical analysis in the hope that we may find provisional answers to a few questions that cannot easily be answered from a general, but not detailed, knowledge of the vegetation and confirmation of certain relationships already suspected. The type of question to which we are curious to know the answer may be exemplified by the following: (1) Does the northern or southern element preponderate? (2) Are there any well-marked barriers to N-S distribution such as the valley of the Zambezi or Limpopo? (3) Do the politico-geographical regions we have used in the Flora represent to any extent phyto-geographical divisions? (4) Can these regions be regrouped into floristically more distinct divisions? We shall attempt to find provisional answers to these and other related questions though recognizing that consideration of a larger sample may later appreciably affect the conclusions arrived at. We think, however, that the present one is sufficiently representative to give interesting results.

Abbreviations used

The following abbreviations of politico-geographical regions have been used: N., W., C., E., S., signifying north, west, central, east and south.

BP. *Bechuanaland Protectorate:* (N), (SW), (SE).

NR. *Northern Rhodesia:* (B=Barotseland), (N), (W), (C), (E), (S).

SR. *Southern Rhodesia:* (N), (W), (C), (E), (S).

N. *Nyasaland:* (N), (C), (S).

M. *Mozambique:* (N=Niassa, Zambezia and Tete Provinces, not merely the Niassa Province as in the Flora Zambesiaca), (S=Manica e Sofala, Sul do Save and Lourenço Marques Provinces). See map, p. 131. QA: Quotient of Affinity; QA (W): Quotient of Affinity calculated by C. B. Williams's method; QS: Quotient of Similarity; QS (K) Kroeber's quotient; QS (S): Sϕrensen's quotient.

The Sample. The sample consists of Gymnospermae and the Angiospermae from Ranunculaceae to Tiliaceae inclusive in the Bentham and Hooker system. Infra-specific taxa have been included as their distributions are quite significant. The sample is fortunately fairly representative, containing typically forest, savanna (we use this term in this work, although it is not employed in the Flora, because there is no other single word available) and aquatic families. Owing to the inclusion of the Annonaceae and Menispermaceae it may be that the forest element is somewhat over-emphasized but not greatly so. The sample probably represents something between 5% and 10% of the whole flora (excluding Cryptogams).

We have excluded from the sample taxa definitely considered to be recent introductions (cultivated plants and weeds clearly of European origin). We have not, however, attempted to exclude cosmopolitan or tropical weeds; for, in a region which has long been inhabited by man, the present vegetation has been so profoundly modified that it is quite fruitless to attempt a reconstruction of what the flora might have been. Moreover, as we go backwards into a hypothetically reconstructed past, the influence of man grades into that of grazing animals (in so far as primitive man kept herds of cattle) in his effect on the vegetation as a whole and grades into that of other animals in his effect on the distribution of the fruits or seeds of individual taxa, whether accidental or with the rudiments of purpose. Even at the present time the influence of grazing animals is difficult to assess in our area and is far from uniform in effect. In the Kalahari Desert, for example, the effect of cattle on the vegetation is negligible, whilst that of game is considerable. The same would apply in parts of the Zambezi and Limpopo Valleys. The influence of abundant game is to make the vegetation more open; if they are removed, bush encroachment is encouraged. Over long periods this effects the distribution of some species (see Mitchell, B. L., 1960). The flora must be considered as it is (with the few exceptions mentioned above), not as it might have been.

Margin of Error. Our figures throughout are not *exact*. Apart from the element of human fallibility in making numerous counts, there have been additions and alterations affecting about half a dozen taxa during the course of our investigation. We could scarcely recalculate all the quotients, etc., every time such a change came to hand. The effect on the quotients would always be much less than 1% and we have never attached any significance whatever to differences in the quotients as small as that.

Similarity and Affinity. It is necessary to explain what we mean in this work by similarity of floristic composition, that is of taxa not of facies. We are not dealing with such matters as the relative abundance of individuals. The floras of two regions might have the same dominants, which would give them a very similar appearance, but if all the other taxa were different (admittedly improbable) they would rank for this investigation as highly dissimilar. If two regions under consideration are disproportionate in floristic richness, the QS is inevitably comparatively small, even if one may have been entirely derived from the other. The QS figures are, therefore, only of useful significance in a comparison between floras relatively similar in size. If floras very dissimilar in size are compared the QS figures tend to become proportionate to the sizes of the smallest members under comparison.

By affinity between two floras we mean derivation of one from the other (or perhaps in both directions) or of both from a common "parent". It is thus either a parent-child or brother-brother type of relationship.

As a measure of similarity existing between one pair (A-B) as compared with another pair (A-C or C-D) we have accepted Søtrensen's QS (Sørensen, 1948) which seems to be the best available. If A represents the number of species in one flora, B the number in the other and X the number of species common: $QS = \frac{2\,X}{A + B} \times 100$. This in effect turns the "similarity figures" into percentages (or spreads them out on a 0 - 100 scale) and makes it possible to compare the similarity between A and B on the one hand with, say, the similarity between C and D on the other.

To find a similar method for expressing affinity, so that the affinity between one pair can be compared with that between another, is more difficult. As the members of a pair become more unequal in size the QS becomes very low, but the affinity (of "parent-child" or "brother-brother" type) may in fact be high. The QA calculation must inevitably involve some kind of compromise and various difficulties are involved. The relationship is bound to "look" different from the point of view of the smaller flora compared with the point of view of the larger flora, for the latter will naturally contain many additional elements. Moreover, although there may be a complete brother-brother relationship (both may be entirely derived from a common source), nevertheless the expectancy will be that even the smaller flora will contain elements not present in the larger one if both have arisen by random selection from a common and larger source. The method used by C. B. Williams (1947) is the only apparently valid one yet published that we know of for comparing the QA of one pair with that of another pair of related regions based on theoretical reasoning. For the sake of those (like ourselves) who suffer from the lack of ability to think in mathematical formulae we shall attempt to give a much simplified summary of this, and a specimen calculation is worked out in detail in the Appendix. Given certain data it is possible to calculate how many species can be expected to be common to two random samples taken from the same flora and if a common origin be postulated for the floras of two related regions they can be regarded as samples of the same flora. If then the calculated expectancy figure for common species (species common to the two samples) be compared with the figure arrived at by actual floristic analysis, we get a relation which we can take as our QA. This is

Williams's QA which we are abbreviating as QA (W). One disadvantage among others from the point of view of the present investigation is that it requires knowledge of the areas of the regions under consideration (Williams, 1947) which sometimes causes considerable difficulty.

The great advantage of QA (W) is its apparently real basis (at least in favourable circumstances), unlike some other formulae which seem to us to be mere juggling with figures divorced from reality.

In the course of working out QA (W), however, for a number of comparisons we have come across certain features that lead us to believe that we cannot put quite as much faith in it as we were at first inclined to do. Williams himself (1947) stated that QA (W) could not be calculated when the areas of the two regions under comparison are too similar. This is quite evidently the case when an attempt is made to compare NR with M. This provides a problem because, if the formula becomes quite unworkable in certain circumstances, producing quite impossible results, it seems to us that there must be a "region of concealed error" in which the results, though apparently credible, must already be suffering some falsification. We do not, in fact, know how different the areas have to be before the results become trustworthy. Secondly, we have discovered that if the larger area has a smaller flora than the smaller area, though the working out of the formula will give a result which may seem feasible, nevertheless there are certain absurdities involved. For example, during the calculation, the number of theoretically postulated common taxa will work out larger than the entire smaller flora, which is, of course, absurd. Since it is by no means a rare phenomenon, in a comparison, to find a larger area with a smaller flora, we suspect again that there may be "regions of concealed error" where this vitiating factor may be at work, though masked. Williams (1947, p. 104) also states "the assumption necessary is that the average density of the population is the same in both areas, or, in other words, that the number of individuals (but not species) is proportional to the areas under consideration". It seems doubtful whether this assumption can be made, especially in comparisons including BP.

We have calculated QA (W) whenever it has been possible to do so, but such possibility is unfortunately limited and, as we have explained above, the formula is sometimes suspect. Comparing NR with M the areas are nearly equal which, as we have said, makes the QA (W) calculation impossible; while in the case of BP-SR the calculation is also impossible by this method (unless our mathematics is at fault) because BP has a much smaller flora, compared with SR, although its area is considerably greater. We therefore thought it better to exclude BP from all QA (W) calculations.

With a number of QA (W) data available we sought some other empirical formula which would produce results sufficiently close to QA (W). We tried expressing the QS (S) as found as a percentage of the maximum possible QS in each comparison. This sounds reasonably convincing as an expression of QA but it reduces itself by simple arithmetic to the expression of the number of taxa common to a given pair as a percentage of the total number of taxa (in the sample) in the smaller member of the pair, which sounds far less impressive but is very easy to calculate. The choice of the smaller member of the pair is not merely an arbitrary one. It is the smaller member which sets the limit to the maximum possible QS. We are abbreviating this formula as QA (EW) for convenience, but with no wish to claim proprietary rights for such a simple method.

We were rather surprised to find the close approximation of the QA (EW) results to those arrived at by QA (W). Table 1 shows a comparison between various QA (W) figures already published by Williams (1947) and the corresponding QA (EW) figures and Table 2 shows a similar comparison between some QA (W) figures and QA (EW) figures calculated by ourselves for various pairs in our own sample.

TABLE 1

Floras compared	*QA (W)*	*QA (EW)*	*QS (S)*	*QS (K)*
S. Tomé - Principe ...	69	67.5	44	49.5
S. Tomé - Annobon ...	71	70	24	42.2
Principe - Annobon ...	49	45	27	32
Fernando Po - S. Tomé ...	49	33.7	27	28
Fernando Po - Principe ...	44	46	23	31
Fernando Po - Annobon ...	41	40	10	23.3
Guernsey - Alderney ...	95.4	92.4	72.5	76

We have added to this Table in the two right-hand columns as a matter of interest QS (S) (expressing similarity rather than affinity) and QS (K) (Kroeber's quotient). The latter is obtained by expressing X (taxa common to two floras A and B) first as a percentage of A, then as a percentage of B, and then taking the mean of these two percentages. We do not know whether it was meant to express similarity or affinity (nor apparently did Kroeber), but it is certainly not a reliable measure of affinity.

It will be seen at once that QS (S) and QS (K) show a rather haphazard relationship with QA (W) and QA (EW) and with each other. On the other hand QA (W) and QA (EW) are fairly closely parallel with the one exception which we have underlined. We cannot explain this discrepancy. QA (W) indicates that the Fernando Po - S. Tomé relationship is closer than the Fernando Po - Principe relationship, while QA (EW) shows the opposite. It is impossible to say which is correct. It is noteworthy that the QA (EW) figures are usually parallel with but slightly lower than the QA (W) figures. This seems to be due to the fact that QA (EW) is an expression of a percentage of a possible maximum, while QA (W) makes allowance for the fact that the theoretical expectancy (according to Williams) is less than the possible maximum, so that the percentages usually work out a little higher.

It is also interesting to note (though perhaps scarcely necessary to mention) that the exclusion of endemics in such calculations raises all the QA and QS quotients; for endemics represent, in this respect, an element of complete diversity reducing, when included, both similarity and affinity quotients. It is proper that they should be included in estimating similarity but there is a case for excluding them in estimating affinity (derivation from a common source). We have not attempted to do this when we come to the comparisons of our samples, partly because the endemics are too few materially to affect the figures and partly because it is too early to be certain whether they are really endemic to a given region or not. For a more general consideration of endemics in our area see page 124.

Confirmation of the parallelism between QA (W) and QA (EW) will be found in Table 10 (page 118), where in only one instance, the SR-M relationship, there is a significant discrepancy for which we can offer no definite explanation, though we think that QA (W) is partly upset because SR is "too rich for its size" in comparison with M.

These rather lengthy preliminaries are necessary to explain the nature of the problems involved and the extent to which QA (EW) may be regarded as a reasonably acceptable substitute for QA (W) when the latter cannot be used.

We have already stated that we think that QA (W) may be suspect in certain circumstances. There is, however, one hopeful feature. QA (W) and QA (EW) are usually fairly closely parallel and when this is the case we think that either of them gives satisfactory quotients and that they to some extent confirm each other. When they differ significantly we suspect (though we are not certain) that one or other of the factors which we know can vitiate the QA (W) result is probably at work.

We can now proceed to our real objective—a statistical investigation of our sample.

External Relations of Flora Zambesiaca Area as a Whole. The first data which we shall consider are those concerning the relationship of the area as a whole to the bordering territories to the north (Congo and Tanganyika), west (Angola and SW. Africa), south (South Africa) and east (Madagascar and the Mascarene Is., separated from our area by the Mozambique Channel, which is some 300-400 km. wide). We shall call taxa extending to the north "N-distrib. elements", those extending to the west "W-distrib. elements", etc., thus avoiding, if somewhat clumsily, expressions such as "N-element" or "S-element" which imply more than we intend to imply. Our "S-distrib. element" means no more than an element which has a distribution extending to the south of our area (parts of it may also extend in other directions) without any implication as to its origin, affinity or direction of migration.

TABLE 2: N,S,W and E Elements (total sample 618 taxa)

N:	359
S:	268
W:	248
E:	38

We had some difficulty in deciding how to deal with SW. Africa since that territory provides a substantial addition to our "W-distrib. element", but also extends considerably to the south of our area. We could not conveniently sub-divide it owing to our firm decision that we should confine ourselves to distributional information obtainable from the Flora itself, partly because of the almost insuperable difficulty that the material used for producing the Flora has already been partly dispersed. We have allotted SW. Africa distributions to both "W-distrib. element" and "S-distrib. element", but any inaccuracy involved in this is small because very few taxa extend to SW. Africa without extending either to Angola or to the Transvaal (or sometimes, of course, to both).

Table 2 shows the first fact of importance to emerge from this investigation. The N-distrib. element is significantly larger than either the W-distrib. element or S-distrib. element, the two latter being approximately equal. The W-distrib. element is, however, almost certainly smaller than it ought to be (see p. 119). Moreover, as we pointed out, our "S-distrib. element" is by no means entirely or necessarily a "southern element" and, although we cannot at present give statistical confirmation, we are convinced that our "S-distrib. element" is considerably augmented by an "overflow" of a tropical flora southwards into the Transvaal and Natal and that this overflow is much greater than any corresponding overflow of a southern element beyond our northern borders. In using the word "overflow" we here accept the implication of a mainly N - S migration though subject, no doubt, to fluctuations due to alternations of wetter and drier climatic periods. Acocks (1953, p. 2) would agree with us here. He considers that a strong tropical African element long ago overran our area, has passed into South Africa and migrated southwards and westwards there.

Secondly, it appears that there is nothing in the nature of a barrier at our N, W or S borders.

Thirdly, the E-distrib. element is relatively small, though by no means negligible. Many of these Eastern elements, e.g., *Dianella ensifolia* (Wild, 1953) and *Faurea forficuliflora*, are either very rare or restricted in distribution. Very likely the number at present known will show a considerable increase with more intensive collecting, although the Mozambique Channel is, naturally, a very effective barrier.

Internal Relations of Flora Zambesiaca Area as a Whole. Our figures under this heading are the result of comparing pairs of subdivisions of our area in a N - S direction and (on a smaller scale) in a W - E direction. We wished to find out whether there were, so to speak, steady gradients or whether barriers could be detected. For the N - S relationship we compared NR(N), NR(C), NR(S), SR(N), SR(C) and SR(S) in adjacent pairs and Table 3 gives the QA (EW) figures and the QS (S) figures for comparison. Table 4 gives comparable figures for the W - E relationship for the subdivisions SR(W), SR(C), SR(E) and M(S).

TABLE 3: The N - S Relationship

		QA (EW)	*QS (S)*
NR(N) - NR(C)	...	58.1	37.5
NR(C) - NR(S)	...	65.1	52.6
NR(S) - SR(N)	...	64.4	62
SR(N) - SR(C)	...	65.9	65
SR(C) - SR(S)	...	62.7	56.2

The easiest way to make our objective clear is to explain that, since the Zambezi separates NR(S) and SR(N), a sudden significant reduction of the quotients at that point (i.e., NR(S) - SR(N) in the table) would tend to show that the Zambezi was a barrier. In fact the QA (EW) figures are quite remarkably uniform, showing that the change in the flora from north to south is a comparatively steady gradient. The comparative smallness of the QA (EW) and QS (S) for NR(N) - NR(C) is due to the inclusion in N R (N) of a considerable "Abercorn element" of Tanganyika relationship containing many taxa not present in (or at least not yet recorded from) our other subdivisions.

The QS (S) figures in the right-hand column are, as usual, much influenced and vitiated by disproportionate sizes (NR(N) has many more taxa, in our sample, than the other four subdivisions).

TABLE 4: The W - E Relationship

		QA (EW)	*QS (S)*
SR(W) - SR(C)	...	67.5	59.6
SR(C) - SR(E)	...	80.8	61.3
SR(E) - M(S)	...	85	70.5

The QA (EW) figures are distinctly higher than in the N - S relationship. They are also more uneven, probably because of a special effect due to the fact that SR(E) and M(S) participate more or less equally in comparatively rich flora of the Eastern Border Mountains.

Apart from the participation of SR(E) and M(S) in the specialized flora of the Eastern Border, the junction of SR(W) and SR(C) more or less coincides with the significant and rather sudden break between the Matabeleland flora, i.e., the *Acacia* - *Colophospermum* - *Terminalia* - *Baikiaea* dry and/or the Kalahari flora of Bechuanaland (less than 30 in. per annum rainfall) and the *Brachystegia* woodlands dominating the plateau of SR(C) (35 in. and upwards). In the case of these two floras not only are the dominant tree-species different but the grass cover is often quite different also, for example *Aristida* spp. are especially common in the west, whilst *Hyparrhenia* spp. are more commonly dominant in SR(C). The QS(S) figures are given as usual for comparison, but we do not in general attach much importance to them for reasons already given. They are also, on the whole, higher than in the N-S relationship.

The real importance here is that the W-E figures are significantly higher than the N-S figures given in Table 3. It will probably be useful to point out what these figures really mean. They are a statistical summary of the distributions of the individual taxa concerned and indicate the preponderance of a definite pattern. The individual areas of distribution are preponderately transversely elliptic or transversely oblong so that the average overlap in a W-E direction is greater than the average overlap in the N-S direction. Stated simply, any given taxon is likely to have a greater W-E than N-S extension. This is in line with the general hypothesis (see Exell, 1957) that the "normal" distribution of a taxon (i.e., when not influenced by special conditions) tends to follow the great circumglobal climatic belts. Although we fully expected this result, we felt some satisfaction in finding this statistical confirmation of it.

It might be thought that this is contradicted by the statement (p. 114) that our N-distrib. element (for the whole area) is greater than our W-distrib. element. It must be remembered, however, firstly that about half the western frontier is that with Bechuanaland Prot., which has an impoverished flora, and that much of the N. Rhodesia - Angola frontier regions are almost uncollected.

Comparison of the floras of the subdivisions used in Flora Zambesiaca (see map).

TABLE 5: Total number of taxa in the sample from the main political divisions of Flora Zambesiaca (and Angola (without Cabinda) abbreviated as A) and the taxa common to them

	TOTAL	Comparative sizes in thousands of square miles	BP	NR	SR	NY	M	A
BP	126	275	—	79	109	48	81	64
NR	326	288	79	—	177	159	180	169
SR	319	150	109	177	—	162	239	131
NY	241	37	48	159	162	—	194	96
M	385	298	81	180	239	194	—	122
A	340	480	64	169	131	96	122	—

This table gives the actual data, but it is necessary, as usual, to transform the figures into quotients before any valid comparison can be made owing to the considerable differences in size (see column 1). The table shows, however, the comparative richness of the various countries.

Mozambique has significantly the richest flora, while those of Northern Rhodesian and Southern Rhodesia are nearly equal (although Southern Rhodesia is much smaller in size). Nyasaland is comparatively rich for its small area and Bechuanaland comparatively poor for its large area. We have added figures from a comparable sample from Angola ("A" in the table) as a matter of interest. Figures for Tanganyika and South Africa would also be interesting but the data are not available at present.

In tables 6 - 9 (below) we give the four quotients QA (W), QA (EW), QS (S) and QK. The first two are quotients of affinity, the third a quotient of similarity, and the fourth of dubious significance, as we have already explained, but certainly a similarity rather than an affinity quotient.

TABLE 6: QA (W)

	NR	SR	NY	M
NR	—	56·3	67·4	—
SR	56·3	—	70·8	85·4
NY	67·4	70·8	—	83·3
M	—	85·4	83·3	—

As we have already explained (see p. 111), this table is perforce very incomplete as it seems impossible to use the method for relationships involving BP and for the NR-M quotient. If it be compared, however, with Table 7 (below), it will be seen to what extent it tends to confirm the reliability of QA (EW) as a substitute (the comparison is easier in Table 10 where they are side by side). As we have already stated, we consider the M-SR figure to be somewhat suspect.

TABLE 7: QA (EW)

	BP	NR	S.R.	NY	M
BP	—	62	87	30	64
NR	62	—	55·5	66	55
SR	87	55·5	—	67·6	75
NY	30	66	67·6	—	80·5
M	64	55	75	80·5	—

TABLE 8: QS (S)

	BP	NR	SR	NY	M
BP	—	35	49	26	31
NR	35	—	55	56	51
SR	49	55	—	58	68
NY	26	56	58	—	62
M	31	51	68	62	—

TABLE 9: QS (K)

	BP	NR	SR	NY	M
BP	—	43	60	23	25
NR	43	—	55	55·8	52
SR	60	55	—	59·5	68·5
NY	23	55·8	59·5	—	65·5
M	25	52	68·5	65·5	—

We have given these tables (Tables 6 - 9) so that anyone interested can compare these different quotients as methods for making floristic comparisons; although in comparing the five territories of the *Flora Zambesiaca* area we shall mainly make use of QA (EW) (Table 7). We have combined these tables together with quotients for Angola (Abbreviated as "A") in Table 10 to facilitate comparison of the four methods. The data for Angola (taken from "Conspectus Florae Angolensis" but with the omission of taxa occurring only in Cabinda) are not up to date and therefore considerably less reliable. We do not give QA (W) for Mozambique - Angola because the larger area has apparently the smaller flora (see p. 111).

Table 10

	QA(W)	QA(EW)	QS(S)	QS(K)
BP–NR	—	62	35	43
BP–SR	—	87	49	60
BP–NY	—	30	26	23
BP–M	—	64	31	25
BP–A	—	51	27·5	35
NR–SR	56·3	55·5	55	55
NR–NY	67·4	66	56	55·8
NR–M	—	55	51	52
NR–A	53·8	52	51	52
SR–NY	70·8	67·6	58	59·5
SR–M	85·4	75	68	68·5
SR–A	42	41	40	39·7
NY–M	83·3	80·5	62	65·5
NY–A	40·3	39·8	33	34
M–A	—	36	33·7	33·9

Note in this table how, when the floras are nearly equal in size as in the NR-SR, NR-M and NR-A relationships, the quotients by each of the four methods give approximately the same results. When the disparity in size is greatest, as in BP-M and NY-M, the quotients become very different and the "similarity quotients" less reliable as any estimate of affinity.

Bechuanaland Prot. (BP). As the number of taxa from Bechuanaland Prot. in the sample (see Table 5 for these figures) is only 126, substantially smaller than those from the other regions, the QS (S) and QS (K) figures cannot be very high (see p. 110). The closest similarity (49) is with SR, sinking to 26 with NY, the latter figure being derived mainly from taxa widespread in the area and usually extending far beyond it. The QA (EW) figures give a more instructive picture (QA (W) cannot be calculated for reasons given on p. 111). The affinity with SR (87) is relatively very high and indicates that the BP flora can practically be considered as an extension (an improverished one) of the SR flora. To put it another way, the Matabeleland flora is almost the same as the Bechuanaland flora but not quite so impoverished. It is perhaps not quite relevant here, but within Bechuanaland there is an impoverishment of individuals westwards as well as of numbers of species.

This particular case shows very clearly how very important it is not to depend on QS quotients if any true measure of relationship (derivation or affinity) is required. The latter quotients (and also the QS (K) quotients) are tremendously affected by any considerable disparity of size.

The distinctive BP element in this sample of the BP flora consists of 7 taxa *(Cleome iberidella, Cleome sulfurea, Cadaba aphylla, Hybanthus densifolius, Polygala seminuda, Melhania griquensis* and *Hermannia guerkeana).* One of them, *Cleome iberidella,* is also Angolan, the other 6 represent a small SW. African element entering our area from the SW.

The QA (EW) figures with NR and Angola (62 and 51 respectively) are fairly high and mainly represent the "Kalahari Sand" element in our flora. The fact that the BP-M figure (QA (EW)=64) is even higher in spite of the considerable distance separating these two territories, is a notable feature which we shall deal with further under SR below. It is an instance of the general phenomenon in our area that W-E affinities are stronger than N-S affinities (see Exell, 1957).

Southern Rhodesia (SR.). The main point of interest is that the QA figures for SR-BP, SR-M and SR-NY are higher than the SR-NR figure, a result we could not have confidently predicted before making this analysis. The W-E affinities are stronger than the N-S affinity. Rainfall is undoubtedly the most important single factor and distribution areas tend to extend in the direction of the isohyets. However much these distributions may be affected by differences of altitude, soil, etc., such effects are insufficient to obscure the rainfall effect in a statistical summary. Even the presence of the comparatively rich montane flora of the Eastern Border Mountains, with its northerly extension into NY and NR(E) (part of the Nyika Placau), does not overshadow the strong W-E relationship.

It seems useful at this point to mention a general effect noticeable not only in the comparison of the politico-geographical regions into which our area is divided for purposes of citation in *Flora Zambesiaca* but also elsewhere when comparisons are made between regions with political boundaries. These boundaries are usually drawn either along watersheds or rivers and in each case a similar effect is observable. Unless the watershed is very high (a mountain range high enough to form an effective barrier and especially if permanently or seasonally snow-clad) the political boundary divides any montane flora (often a rich one) between the adjacent regions, contributing a more or less equal element to each of them, with a considerable statistical "damping down" effect on any floristic differences which the mountain-chain (or elevated watershed) may cause through acting as a barrier. The same applies to a river-boundary because any special valley-flora is again divided between the adjacent regions and allotted to each of them. We shall deal a little further with this matter under the heading *Barriers* (see p. 121).

In view of the above it may well be thought that our politico-geographical divisions and subdivisions are ill-chosen for botanical purposes. It is, however, essential to choose divisions of this kind, firstly because a great number of specimens are insufficiently localized to permit citation unless divisions of this general nature are selected, and secondly because any attempt at phytogeographical divisions and subdivisions based on purely ecological grounds inevitably results in an intricate pattern quite unsuitable for the purpose. The criticism may be made that it is a waste of time to make comparisons between regions delimited by political or administrative boundaries, but at least we find it "interesting", for example, to be able to say that the QA figures show that, as far as our sample is concerned, Southern Rhodesia shows a closer floristic affinity with Mozambique than with Northern Rhodesia.

As regards the subdivisions of SR. (and this also applies to the subdivisions of the other territories) our present investigation of a sample does not permit of any detailed comparison between them, nor are they entirely suitable for such a purpose. For comparisons of a more ecological nature (see Wild, 1956, pp. 10-11) indicating differences between the highveld and lowveld floras, differences due to altitude and soil, etc., a different type of investigation is required.

Northern Rhodesia (NR.). As is to be expected, affinity and similarity with the flora of Angola are stronger than those shown by any other territory in our area. The QA with NY is greater than with SR, though the QS (S) figures are almost the same (56 and 55 respectively), the similarity figure with NY being, as usual, automatically reduced by disparity in size. The QS (S) and QA (EW) with M are slightly smaller than those with SR, which seems to contradict our general thesis that W-E affinities are stronger than N-S affinities. This may be due to a probability that northern Nyasaland (Nyika and Vipya Mts. and Lake Nyasa) constitutes, to some extent, a barrier to W-E distribution, to the fact that N.R. and M have only a comparatively short common frontier and to the fact that the regions where they are in contact (southern part of NR (E) and northern part of M (T)) are still inadequately collected.

The incidence of collecting undoubtedly considerably affects the NR statistics in several respects. The extensive collections made by Milne-Redhead in the extreme NW., those by Mrs. Richards and others in the Abercorn District and the very complete collections made in the Victoria Falls region increase the recorded relationships with Angola (though still probably smaller than it should be), Tanganyika and Southern Rhodesia respectively, while there are only much smaller collections from the frontier with Mozambique.

Nyasaland (NY). The QA (EW) figure between NY and M is very high (80.5) and the QS (S) figure (62) is also high when account is taken of the disparity in size. Since NY is largely an enclave in M, this is to be expected. NY might practically be considered as a part of M as far as this investigation is concerned. Rather unexpected is the fact that both QA (EW) and QS (S) with SR come out distinctly higher than with NR, partly, no doubt, for some of the reasons we have given in attempting to explain the relatively low NR-M figures, but principally because of the Chimanimani - Inyanga - Mlanje - Nyika relationship as Subcentres of the Cape flora (Weimarck, 1951).

Mozambique (M). The comparative richness of the flora (number of taxa) is probably due to the considerable N-S extension giving, on our general hypothesis, greater diversity than a W-E extension, to the great differences in altitude, to the presence of a littoral element naturally absent from the other territories and to its comparatively large area. The richness is, however, only relative and in comparison with S. Rhodesia, when account is taken of the difference in area, we suspect that the Mozambique flora is "less rich than it ought to be" or, in other words, there are many more species yet to be recorded. This may be the cause of the discrepancy in the QA (W) and QA (EW) figures for SR-M in Table 10.

We have already mentioned the high QA with SR. This results from the fact that the rich flora of the Eastern Border Mts. is shared by the two countries, that the wide river valleys facilitate W-E and E-W migrations and that SR and the southern part of M are regions from which our collections are probably fairly complete. Nevertheless, this high affinity (QA (EW)=75) is one of the most striking features of the investigation.

It might be as well to mention again at this point that the incidence of collecting has not been uniform throughout our area so far and that this will mean that some degree of correction will be necessary to both the total figures for the individual territories and also to their subdivisions. It seems likely that the South West African border country in Bechuanaland Protectorate is badly undercollected, affecting BP (N) and BP (SW), whilst SR (C) and the Lourenço Marques Districts in Mozambique must be almost completely collected. The degree of undercollection elsewhere is probably fairly uniform, except that it may be accepted that NR (B), NR (E), NY (N), NY (C), M (N) and SR (S) are not so well collected as the remainder. Generally speaking, therefore, one should allow for an upgrading of all Bechuanaland figures, but as the flora is so markedly impoverished, this will not be likely to affect any of the conclusions relating to Bechuanaland. Mozambique figures as a whole will increase and, in comparison with the other territories, the figures relating to S. Rhodesia will require less adjustment.

Barriers. The figures tend to show that the only discernible barrier within the area is northern Nyasaland, where the Nyika and Vipya plateaux, in conjunction with the comparatively broad and low-lying lake, seem to form a partial barrier between NR and northern Mozambique, but more collecting is necessary before this can be definitely established.

The Zambezi Valley does not seem to be a barrier at all; but we have already discussed the partial obliteration of statistical effects by the choice of rivers as boundaries. A river itself is in any case probably never a barrier. A river valley may be so if it is sufficiently wide and at the same time sufficiently deep to produce a local microclimate. Given both these features, and given observable differences in the flora on the two sides, care must still be taken before coming to the conclusion that the valley is a barrier. If the river runs more or less N-S or S-N and if the said differences are observable, the valley may prove to be a barrier in a real sense. The more important rivers in our area tend to run W-E and in this case one has to be more careful; for if the valley is broad enough to form a possible barrier to migration, the rainfall to the north will tend to be appreciably higher than the rainfall to the south and floristic differences might be just as great even if the river were not there.

However, one example of a species which finds the Zambezi Valley (but not the river) a barrier is *Brachystegia allenii* which in moving southwards reaches the escarpment south of the Zambezi but does not get beyond it, thus behaving in a way reminiscent of, but not precisely similar to, *Brachystegia spiciformis*, which stops short at the Limpopo Valley but gets no farther than the northern escarpment. An examination of possible reasons for these facts is interesting. It may be that we are dealing with a flora which is in a state of dynamism and consequently any barrier may be either real or imaginary, i.e., the limit to the distribution may be due to an impediment (real) or may be merely the limit reached in time (no barrier, merely an imaginary one). Thus, in the case of these two *Brachystegia* species it may be that they are in progress of migrating southwards and are only temporarily stopped at these so-called barriers. This may be specially likely in the case of *Brachystegia* spp. since it is possible that the difficult problems of their taxonomy, their speciation and ready hybridization show that they are a young and vigorous group of species and it may be that this burst of speciation has stimulated a more rapid rate of migration than would normally be the case. Alternatively, *Brachystegia spiciformis* may have been halted at the Limpopo because of the too great prevalence of frost in the Transvaal or some other climatic or edaphic factor. It is difficult to decide between these alternatives.

In a statistical investigation, owing to the "damping down" effect of a local flora shared by two adjacent regions (see p. 119), to test the efficacy of a supposed barrier it would be necessary to compare statistically the floras of the escarpments on each side of the valley itself. Otherwise the differences tend to be obscured to such an extent that they may not be distinguishable from what one might call the "normal" differences. We have not, at present, data available to make such an investigation.

In speaking of barriers it is necessary to make one more point. In saying that few important barriers exist we mean that they do not show up statistically. The region, for all we know at present, may be and probably is full of barriers to individual taxa. Any limited distribution indicates either barriers of one kind or another or lack of geological time for the distribution to have become further extended. A barrier in our sense is characterized by the coincidence (more or less) of the lines marking the limits of distribution, in one direction, of a number of taxa sufficiently large to produce a significant statistical effect.

As we have already postulated (see p. 116), the "normal" distribution of taxa tends to follow the circumglobal climatic belts producing a general pattern of transverse ellipses or oblongs. This can often apply, given the chance, with the Cape element that in our area normally follows a N-S line along our eastern border into Nyasaland. See the Western extension of this cited by Wild (1956). Africa is probably the continent in which these climatic belts are least disturbed by various secondary factors and such N-S features, mountain-chains, etc. (see Exell, 1957), are of especial interest. They naturally tend to upset the general distribution, replacing (or at least supplementing) the W-E ellipses by comparatively narrow distribution patterns with N-S extension. When this phenomenon occurs it does not, however, necessarily indicate an effective barrier. Our Eastern Border Mts. (with extensions in Nyasaland) constitute a well-known and well-marked line of N-S distribution, but they do not form a very effective barrier between S. Rhodesia and Mozambique (hence the comparatively high QA figures between the two countries). The reason for this is that they do not form an unbroken chain, at least in the south. The valleys of the Limpopo, Sabi and Zambezi form excellent channels for W-E and E-W migration (see Wild, 1951, p. 10).

The climate of our area generally, in comparison with that of neighbouring territories, as well as the more important climatic differences within the area, naturally have an influence on the migration and distribution of many of our species. The bulk of our area falls within the tropics and is a summer rainfall region, but the amount of rainfall varies tremendously. The 5-10 inches per annum of South West Bechuanaland Protectorate supports a flora with the closest affinities to that of most of South West Africa, whilst the 60-100 inches per annum, or more, of the Eastern Mountains also produces its own distinctive flora. Frosts are fairly common in the dry winter of the plateau country in the Federation, but are much more severe in the Transvaal. This no doubt forms a barrier to many of our more tropical species and possibly to the southward migration of *Brachystegia* spp. (see p. 122). The mean annual temperature of much of our plateau country usually lies between 60° F. and 70° F., and temperatures above 90° F. are rare. In the Zambezi, Shire and Limpopo Valleys, however, mean annual temperatures are often above 80° F. and temperatures above 100° F. not uncommon. This helps to produce the kind of valley microclimate referred to on p. 122 and may provide a barrier to some species and encourage endemism (p. 126).

There are also some important barriers to N-S distribution, not in the form of mountain-chains but in the form of upland masses sufficiently elevated to cause considerable climatic changes reinforced in their floristic effect by their leached and often acid soils so that, from north to south, we get alternations of eluvial and alluvial soils separated by bands of colluvial soils on the escarpments. This begins to go beyond the scope of this mainly statistical investigation, but it is, nevertheless, interesting to point out the theoretical effect (substantiated by many well-known though not statistically investigated distribution patterns) of W-E barriers of this nature. The effect is to increase the proportion between the W-E longer axes and the N-S shorter axes of the transverse ellipses or oblongs by shortening their N-S axes by the action of barriers extending W-E. An excellent example of this is given by the distribution pattern of *Colophospermum mopane* and some of its associated species forming a belt right across the continent along the Kunene - Zambezi depression and a somewhat shorter but still greatly extended belt along the valley of the Limpopo.

Examples of associated species which show patterns which are identical, or whose distributions approximate to this pattern, are as follows:—*Maerua parvifolia, Boscia albitrunca, Xylopia odoratissima, Acacia fleckii, Acacia mellifera* subsp. *detinens, Cyphostemma congestum* (Cissus fleckii) and C. subciliatum.

Endemics. The figures for endemics in our sample are B.P.1; S.R.5; N.R.13; Ny.5; M.24; with other species endemic to more than one territory. A more detailed consideration of endemics in our area is, however, not at all straightforward. It is obvious that, as the *Flora Zambesiaca* area or its component political divisions have primarily political boundaries in the midst of a large continent, the term endemic applied to one of these political divisions, or to the whole area, will often be meaningless. It is perhaps possible, however, to apply the term endemic in certain areas which fall more or less accidentally within the boundaries of one of our political divisions or in some cases where these areas cross our main boundaries. These areas will be those that by reason of altitude, climate or soil are segregated ecologically as "islands" from the remainder of our area.

The most important of these groups of "ecological islands" is that represented by the eastern mountain chain along the borders of S. Rhodesia and Mozambique and in Nyasaland with many small outliers, especially in Mozambique. The mountain chain itself is divided into distinct units separated by fairly deep and wide river valleys forming barriers of varying importance. The more important units of this system are the Nyika plateau, the Vipya and Mlanje Mountains in Nyasaland and Inyanga, the Vumba and the Chimanimani Mountains along the border between Mozambique and Southern Rhodesia. Its outliers are represented by such mountain masses (or sometimes inselbergs) as Gorongoza Mt., the Gúruè Mts. and the Sitatonga Hills in Mozambique and the raised portions of the northern escarpment of the Limpopo (Wild, 1956). The majority of species in the floras of these mountains are common to other parts of the Centres and Subcentres of the Cape Flora or to other mountain masses in Africa (Weimarck, 1951), but because of the isolation of these mountains both in space and climatically for long periods, they have also developed genuine endemics. Within this mountain complex endemics may naturally be more or less restricted. If allowance is made for poor taxonomy there remains a well defined group of what are almost certainly true endemics. Some good examples are:—*Aeschynomene aphylla* (Chimanimani Mts.), *Aeschynomene inyangensis* (Chimanimani Mts. and Inyanga), *Protea enervis* (Chimanimani Mts.), *Erica gazensis* (Chimanimani Mts.), *Hibiscus burtt-davyi* (Chimanimani Mts. and Mt. Mlanje), *Dombeya lastii* (Gúruè Mts.), *Cleome densifolia* (Mt. Mlanje), *Ericinella brassii* (Mt. Mlanje), *Ericinella microdonta* (Mlanje and the Nyika) and *Helichrysum brassi* (Nyika, Mlanje and Namuli (P.E.A.)).

A good number more can readily be found in:—Brenan (Plants Collected by the Vernay Nyasaland Expedition of 1946 in Mem. N.Y. Bot. Gard **8**, 3 & 5 (1959) and **9**, 1 (1954)) and Rendle et al (A Contribution to our Knowledge of the Flora of Gazaland, Journ. Linn. Soc., Bot. **40** (1911)). Our knowledge of this type of endemic could also be greatly added to if an intensive taxonomic study of the vicarious taxa of our mountainous areas were made on the lines of Hedberg (Afroalpine Vascular Plants (1957)) in dealing with the East African montane flora.

The next group of endemics is that confined to the ecological island formed by the norite, pyroxenite, serpentine and chrome seams of the Great Dyke in S. Rhodesia. This forms a narrow strip up to about five miles wide and 300 miles long, running from NNE in the Sipolilo area to SSW in the Belingwe District. Some species such as *Cyphostemma humile* are entirely confined to the Great Dyke in S. Rhodesia but occur also outside our area and, in the case of *C. humile* which is also found in the Transvaal and Natal, on quite different soils. There are others, however, which appear to be genuinely endemic to the Dyke soils, for example, *Aloe ortholopha, Euphorbia memoralis, Euclea eylesii* and several undescribed species in the genera *Pearsonia, Blepharis* and *Merremia*. As the Great Dyke stops short at the Zambezi escarpment in the north and the Limpopo escarpment in the south, species confined to its soils are naturally endemic to S. Rhodesia.

Another case of the same kind but on a much larger scale is that provided by the Kalahari Sand deposits. These, of course, are not confined to our area but extend into Angola and SW. Africa, consequently some well-known species such as *Baikiaea plurijuga*, which occur throughout the Kalahari Sand areas, are not endemic to our area. On the other hand there are some species confined to some parts of the Kalahari which are distributed entirely within our boundaries; there are, for instance, certain species occurring in the so-called Kalahari Desert in SW. Bechuanaland which contribute an endemic element to our flora. Examples of these are:—*Cleome sulfurea, Neuradopsis grieloidea* and *Neuradopsis bechuanensis*. For further examples see Bremekamp, C. E. B., and Obeymeyer, A. A. (1935) in Ann. Transv.

Mus. **16**: 26-442. Some of these species may, of course, be eventually found in neighbouring areas of SW. Africa. A Kalahari endemic of the Baikiaea areas is *Dichapetalum rhodesicum*, known only from Barotseland and Matabeleland (SR (W)). It must also occur in Northern Bechuanaland.

The valleys of the Zambezi and Limpopo, as has been said elsewhere in this paper, often provide a path of distribution for species such as *Colophospermum mopane* which extend from the east to the west of southern Africa. There are some other species, however, occurring in these two valleys which do not pass over into the Kunene system from the Zambezi or into SW. Africa from the Limpopo. They thus form another group of endemics, some occupying only relatively small areas within these valleys. In the case of Zambezi Valley species they will scarcely ever be confined to one territory due to the fact that the Zambezi divides N. Rhodesia from S. Rhodesia. Examples are:—*Triplochiton zambesiacus* (N. Rhodesia and S. Rhodesia only), *Commiphora karibensis* (N. Rhodesia and S. Rhodesia only), *Pterocarpus brenanii* (S. Rhodesia, Nyasaland and Mozambique), undescribed species of *Cyphostemma* and *Erythroxylum* (N. Rhodesia and S. Rhodesia) and *Citropsis daweana* (Bechuanaland, S. Rhodesia, N. Rhodesia and Mozambique). This latter spreads well south of the Zambezi in the coastal plain of Mozambique but should be considered with this group of species. These we may call the Zambezi endemics and there is a similar group of Limpopo endemics. Species more or less confined to the Limpopo Valley, however, are naturally almost invariably present in the Transvaal or Northern Cape Province and are not therefore endemic to our flora. They also tend to spread within our area into south-western and south-eastern Bechuanaland. A few examples are:—*Grewia hexamita* (Mozambique, S. Rhodesia and the Transvaal); *Jatropha messinica* (Transvaal and S. Rhodesia); *Fagara humilis* (Transvaal and S. Rhodesia); *Acacia borleae* (Mozambique, Swaziland, Transvaal and S. Rhodesia); and *Acacia permixta* (Transvaal and S. Rhodesia). The number of species that could eventually be listed in this category is probably surprisingly large.

Finally, a significant number of endemic species with very restricted distributions are to be found in the Abercorn District of N. Rhodesia. In this area it is becoming apparent that certain genera such as *Crotalaria* and *Cyphostemma* have developed a remarkable tendency towards the production of new species. Many of these species occur also in Tanganyika just across the border and also in the Congo, but in spite of very intensive collecting in this area many of these species appear to have very restricted areas of distribution indeed and are apparently endemic to N. Rhodesia. Here we are not, so far as one can see, dealing with an ecological island, instead it seems that in some way conditions are specially favourable for the production of new species, as is the case, for example, in the Cape. As most of the examples involved in these two genera are as yet undescribed it is not possible to quote them satisfactorily at present, but a parallel case is worth mentioning with regard to *Cyphostemma* in the Katanga. If we consult Mlle. Dewit's recent revision of the *Vitaceae* in the Flore du Congo Belge **9** (1960) we find that in *Cissus* sect. *Cyphostemma** there are twenty-four species apparently confined to the Katanga out of fifty-four for the whole Congo. In addition there are three others recorded that only extend beyond the Katanga into N. Rhodesia. In fact it is now possible to say that several more of these Katanga species also extend into N. Rhodesia, but as a rule only into the Copperbelt. Apart from saying that both the Katanga and Abercorn areas support an extremely vigorous type of *Brachystegia* woodland, with a great diversity and number of herbaceous species of all kinds, one can offer no explanation of their tendency to produce many species with restricted distributions in certain genera. There is no doubt, however, that this tendency can be prolific in increasing the number of endemics.

Endemism, except when it is due to the presence of relict species, is presumably to be estimated on some correlation between the number of species which have evolved and also their age, in that a region rich in species or in which many species have evolved will not show a high rate of endemism if these species have had time or potentiality, or both, in which to extend their ranges into other territories. We may, therefore, suppose that a region such as the Abercorn region has comparatively recently reached a condition favourable to the production of new species.

In conclusion, we reiterate that our observations are based on what is after all a sample representing less than 10 per cent. of the total flora. It will be interesting to see at some rather distant date whether they are confirmed by statistics based on the whole flora, if anyone has the patience to undertake an investigation which, judged by the time required in analysing our comparatively small sample, cannot fail to be a very laborious one.

APPENDIX

At the request of several colleagues we append the full working out of QA (W), QA (EW), QS (S) and QK. The QA (W) calculation is the only one with any element of intricacy: the other three are very simple. The quotients are worked out below for Nyasaland-Mozambique, chosen because this pair best illustrates the differences between the quotients. Various figures are given for the area of Nyasaland: we have chosen the smallest of these, which excludes the area of the lake.

Relevant data

Area of Mozambique (required only for QA (W)): approx. 298,000 sq. miles.

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* Mlle. Dewit treats (loc. cit.) *Cyphostemma* as a section of the genus *Cissus* L. However, Alston in Trimen, Handb. Fl. Ceylon **6**, Suppl.: 53 (1931) raised it to generic rank and this example has been followed recently by Descoings in Not. Syst. **16**: 113-125 (1960). *Cyphostemma* (Planch.) Alston will also be considered as a distinct genus in the account of the *Vitaceae* at present being prepared for inclusion in Vol. 2 of the Flora Zambesiaca.

Area of Nyasaland (required only for QA (W)): approx. 37,000 sq. miles.

Only the proportion is required so we have taken 298 and 37 respectively.

Total taxa (in the sample): Mozambique 385; Nyasaland 241.

Total common to the two countries: 194.

QA (W)

Those interested in the reasoning on which Williams based his formula for calculating QA (W) should consult his own papers on the subject (Williams, 1947). We give here only the calculation from the data given above. T=the theoretically expected total number of species in the floras of the two countries combined.

$\propto$ = Williams's "index of diversity".

The two simultaneous equations required are:

$$T - 385 = \log_e \frac{298 + 37}{298} = 0.1168 \times \propto$$

$$T - 241 = \log_e \frac{298 + 37}{37} = 2.2039 \times \propto$$

Subtracting the first from the second:

$$144 = \propto \times 2.0871$$

Therefore $\propto = 69$ (approx.)

Substituting in the first equation (either will do)

$$T - 385 = 69 \times 0.1168$$

$$T = 393$$

Subtracting this figure (393) from 626 (385+241) the sum of the total number of taxa in each of the two countries, we get 233 and this is the theoretical expectancy of taxa common to the two countries on the assumption that both floras are derived from a common source. If we now express 194 (the number of common taxa actually found in the sample) as a percentage of 233 (the number of common taxa theoretically expected) we get 83.3, which is QA (W). If the areas are too close in size the calculation cannot be made, as Williams himself has pointed out.

Furthermore, it seems that when the region with a larger area has a smaller flora (e.g., Bechuanaland Protectorate and S. Rhodesia) the method is inapplicable or at least it appears so to us (but we may, of course, be wrong).

QA (EW)

This is extremely simple, being merely the expression of the common taxa as a percentage of the smaller of the two floras under consideration. The choice of the smaller flora is not merely arbitrary. It represents the possible maximum of species in common. We have shown that in practice QA (EW) is usually a fairly close approximation to QA (W) (the difference is rarely more than 5 per cent.) so that QA (EW) is near enough for a series of comparisons and can also usefully be used, when the QA (W) quotient is being employed, as a rapid check on the QA (W) calculation and as an indication when the latter may be affected by a vitiating factor.

The example works out as follows:

$$\frac{194 \times 100}{241} = 80.5 \text{ (approx.)}$$

QS (S)

This works out simply as:

$$\frac{2 \times 194}{385 + 241} \times 100 = 62$$

It seems to express similarity in a fairly satisfactory way but it makes no real allowance for disparity in size so that if the sizes of two floras under comparison are very different it provides no good standard for comparing affinities. Already in this example the divergence from the QA figures is considerable.

QS (K)

Kroeber's quotient works out as:

$$\frac{\dfrac{194 \times 100}{385} + \dfrac{194 \times 100}{241}}{2} = 65.5 \text{ (approx.)}$$

It is a matter of chance that it approximates fairly closely to QS (S) in this example. Sometimes the two quotients differ quite widely (e.g., see Table I: Fernando Po - Annobon).

These four quotients, QA (W), QA (EW), QS (S) and QS (K) are all the methods we know of which have been used (QA (EW) for the first time as far as we are aware, but it is so simple that others may well have used it) for the floristic comparison in pairs of a series of floras. We hope that we have succeeded in showing that the problem is not so easy as at first sight appears and that different methods can give strikingly different results once the "disparity of size" factor becomes important.

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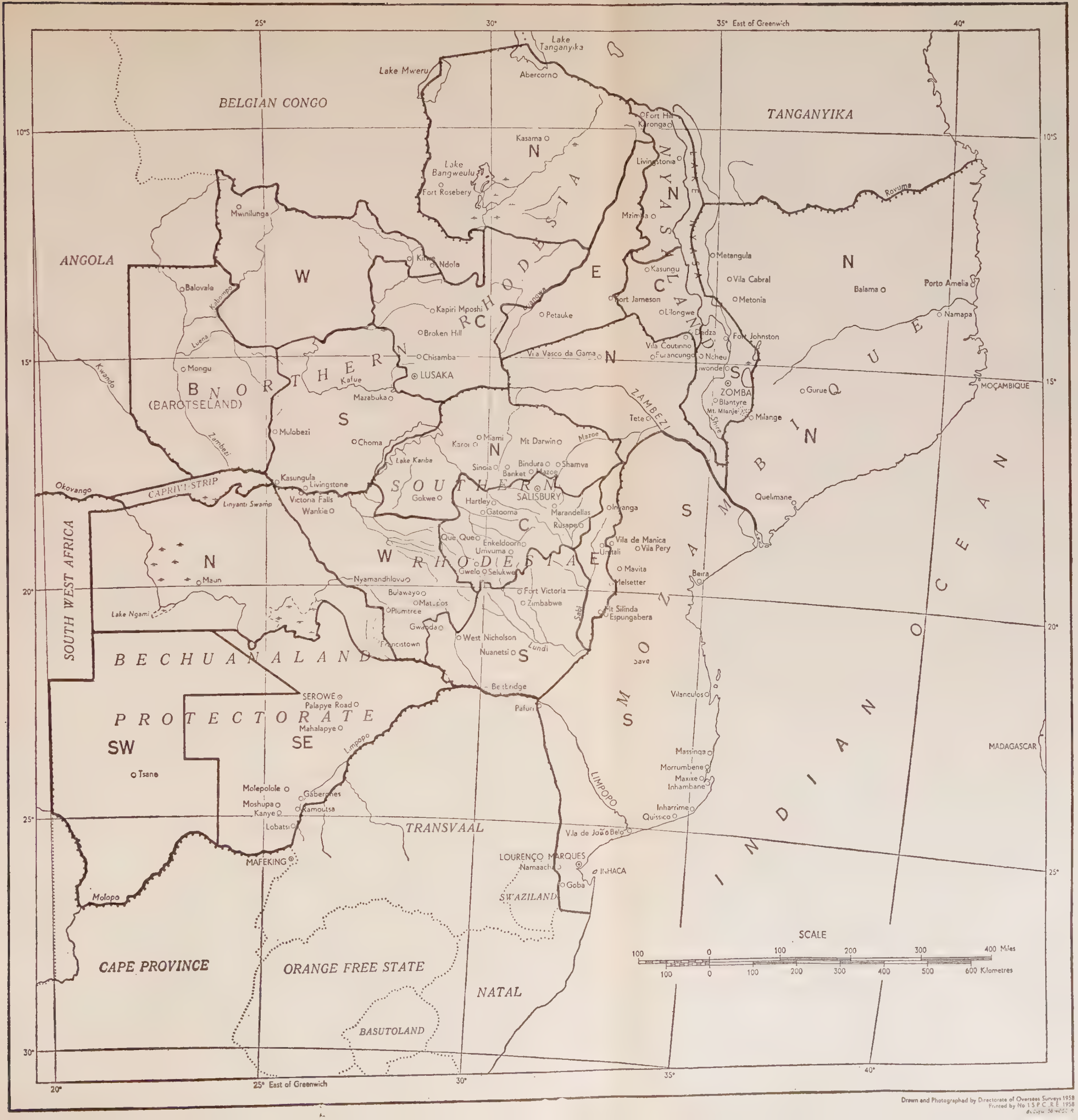
FLORA ZAMBESIACA



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VITACEAE FROM THE *FLORA ZAMBESIACA* AREA: 2

by

H. Wild & R. B. Drummond

Cyphostemma abercornense Wild & Drummond, sp. nov.

C. vandenbrandeano (Dewit) Descoings affine sed caulibus ecirrhosis, fructibus glabris et foliis 3-5-foliolatis differt; *C. septemfoliolatae* Wild & Drummond affine sed caulibus prostratis foliis 3-5-foliolatis differt.

Herba prostrata; caules ramique longitudinaliter striati, brunneo-tomentosi vel pubescentes, ecirrhosi. *Folia* digitata, 3-5-foliolata; petiolus 0.4-4.0 cm. longus, tomentosus vel dense pubescens; foliola subsessilia aut petiolulis ad 1 cm. longis, oblanceolata, apice acuta vel subobtusa, basi cuneata, margine dentibus apiculatis serrata; pagina superior glabra praeter nervum medium puberulum; pagina inferior albidis vel ferrugineis pilis villosa interdum demum pilosa, nervis venisque reticulatis; foliolum medianum ad 15 × 5 cm.; foliola lateralia ad 9 × 2.5 cm. *Stipulae* ad 1.5 × 0.8 cm., persistentes, oblongo-lanceolatae, acuminatae, tomentosae vel pubescentes. *Cymae* compositae, usque ad 11 cm. diam., pedunclo ad 4.3 cm. longo; pedunculus et axes tomentosi vel pubescentes; bractae et bracteolae ad 3 mm. longae, lanceolato-subulatae, pubescentes. *Flores* pedicello ad 3 mm. longo, pubescente vel sparsissime pubescente. *Alabastrum* ad 2.3 mm. longum, cylindricum, ad medium leviter constrictum. *Calyx* 0.5 mm. longus, subinteger, pubescens. *Petala* flavida vel rubra, c. 2 mm. longa, glabra vel subglabra. *Stamina* 1.7 mm. longa; antherae 0.4 longae. *Ovarium* glabrum; stylus 1.5 mm. longus; stigma indistinctum. *Baccae* immaturae glabrae.

Type: *Richards* 7294 (K, holotype).

NORTHERN RHODESIA. Northern Province: Abercorn Distr., Mpulungu Rd. near Mukoma Turning, sandy soil, 1400 m., fl. 17.xii.1956, *Richards* 7294 (K):—semi-prostrate, flowers yellow: Chinsali Distr., Machipara Mt., Shiwa Ngandu, sandy rocky soil on mountainside, 1500 m., fl. 16.i.1959, *Richards* 10707 (K).

Cyphostemma barbosae Wild & Drummond, sp. nov.

C. glandulosissimo (Gilg & Brandt) Descoings affine sed plantis erectis, caulibus ramis petiolis, foliolisque pilis elongatis glandulosis ad 1.4 cm. longis praeditis, alabastris pubescentibus et pilis glandulosis intermixtis donatis distinctum; *C. woodii* (Gilg & Brandt) Descoings affine sed foliis sine pilis glandulosis sessilibus.

Herba erecta vel suberecta, radicibus tuberosis crassis; caules ramique striati, pubescentes vel glabrescentes et pilis glandulosis elongatis ad 1.4 cm. longis praediti; cirrhi glandulosi, bifurcati interdum absentes. *Folia* digitata, 3-7-foliolata; petiolus ad 16 cm. longus, pubescens vel glabrescens et pilis glandulosis elongatis praeditus; foliola subsessilia, late elliptica vel circulares, apice acuminata, basi cuneata, margine apiculato-crenata; pagina superior sparse breviter stipitato-glandulosa; paginia inferior praecipue ad nervos majores pilis glandulosis stipitatis praedita; foliolium medianum ad 19 × 8 cm.; foliola lateralia ad 13 × 9 cm. *Stipulae* ad 2 cm. longae, lanceolatae, acuminatae, falcatae, margine pubescentes et sparse glandulosae. *Cymae* compositae, usque ad 20 cm. diam., pedunculo ad 12 cm. longo; pedunculus et axes pubescentes et pilis glandulosis ± elongatis praediti; bractae et bracteolae ad 1.2 cm. longae, lineari-lanceolatae, acuminatae, margine pubescentes et sparse glandulosae. *Flores* pedicello ad 1.2 cm. longo, puberulo et pilis breviter stipitato-glandulosis praedito. *Alabastrum* c. 3.5 mm. longum, cylindricum, ad medium constrictum. *Calyx* c. 0.7 mm. longus, subinteger, dense pubescens. *Petala* c. 2.7 mm. longa, pubescentia et apici pilis glandulosis praedita. *Stamina* c. 2 mm. longa; antherae 0.3 mm. longae. *Ovarium* glandulosum, stylus 2 mm. longus; stigma indistinctum. *Baccae* rubrae, c. 1 × 0.7 cm., ellipsoidae, stipitato-glandulosae, semine unico; semen c. 8 × 5 mm., ± laeve.

Type: *Barbosa* 728 (LISC, holotype; LM).

MOZAMBIQUE. Lourenço Marques: Namaacha, fl. *Gomes e Sousa* 147 (LISC); ibid., fr. 22.xii.1944, *Torre* 6930 (LISC); ibid., fr. 9.xii.1948, *Myre & Carvalho* 296 (LM; SRGH). Maracuene, between Namaacha and Boane, fl. 16.x.1940, *Torre* 1796 (LISC). Maputo, Goba, fr. 6.xii.1942, *Mendonça* 1663 (LISC); ibid., fr. 22.xi.1944, *Mendonça* 3011 (LISC); ibid., fr. 22.xii.1944, *Mendonça* 3427 (LISC); ibid., fl. & fr. 14.xii.1947, *Barbosa* 728 (LISC; LM).

It gives us great pleasure to name this species in honour of our old friend Eng. Luis Augusto Grandvaux Barbosa.

Cyphostemma hermannioides Wild & Drummond, sp. nov.

C. sessilifolio (Dewit) Descoings affine sed foliolis lateralibus multo minoribus.

Herba prostrata; caules ramique longitudinaliter striati, tomentosi vel pubescentes, ecirrhosi. *Folia* digitata, 3-foliolatae; petiolus 0-2 mm. longus, tomentosus vel dense pubescens; foliola sessilia aut petiolulis ad 2 mm. (ad 6 mm. in mediano foliolo) longis, margine dentibus apiculatis crenata; pagina superior glabra sed margine et nervo medio puberulo; pagina inferior nervis venisque dense pubescens; foliolum medianum ad 9.5 × 6 cm., late ellipticum vel anguste obovatum, apice obtusum, basi cuneatum; foliola lateralia ad 3.5 × 3 cm., late ovata, obovata vel late obovata, apice acuta vel rotundata, basi asymmetrica, rotunda. *Stipulae* ad 6 mm. longae, persistentes, oblongo-lanceolatae, ± falcatae, acutae ad acuminatae, pubescentes. *Cymae* compositae, usque ad 4.5 cm. diam., pedunculo ad 2.5 longo; pedunculus et axes dense pubescentes; bracteae et bracteolae c. 1 mm. longae, subulatae, pubescentes. *Flores* pedicello ad 1.7 mm. longo, pubescente vel sparsissime pubescente. *Alabastrum* c. 1.7 mm. longum, cylindricum, ad medium leviter constrictum. *Calyx* c. 0.25 mm. longus, subinteger, puberulus. *Petala* flavida et rubra, c. 1.5 mm. longa, glabra. *Stamina* c. 1.3 mm. longa; antherae c. 0.25 mm. longae. *Ovarium* glabrum; stylus c. 1 mm. longus, apice minute bifidus. *Baccae* rubrae, c. 8 mm. diam., subglobosae, glabrae, semine unico; semen c. 6 × 4 mm., ellipsoidum, rugosum.

Type: *Richards* 3594 (K, holotype; SRGH).

NORTHERN RHODESIA. Northern Province: Lake Tanganyika, Mpulungu, sunny bank near lake, fr. 29.xii.1951, *Richards* 181 (K): creeping. Lunzua Valley, sandy soil, 1,000 m., fl. 2.xii.1954, *Richards* 3594 (K; SRGH). Lake Tanganyika, Mpulungu, sandy soil, woodland, 800 m., fl. 16.i.1954, *Richards* 3657 (K).

This species bears a superficial resemblance to some species of *Hermannia* with large stipules such as *H. transvaalensis* Schinz. The lateral leaflets of *Cyphostemma hermannioides* at first sight resemble stipules.

Cyphostemma lovemorei Wild & Drummond, sp. nov.

C. bororensi (Klotzsch) Descoings affine sed pedicellis eglandulosis, foliolis manifeste petiolulatis.

Herba scandens; caules ramique longitudinaliter striati, glabri; nodis pilis stipitato-glandulosis sparsissime praediti. *Folia* digitata, 5-foliolata; petiolus ad 2 cm. longus, glaber; foliola glauca, semi-succulenta, petiolis ad 2.2 cm. (ad 3 cm. in mediano foliolo) longis, oblongo-elliptica vel anguste ovata, apice acuta vel subacuta, basi cuneata vel obtusa, margine ± sparse dentibus acuminatis serrata, utrinque glabra; foliolum medianum ad 9 × 4 cm.; foliola lateralia ad 7 × 3.5 cm. *Stipulae* c. 7 mm. longae, lanceolatae, acuminatae, ± falcatae, glabrae. *Cymae* laxae, compositae, usque ad 14 cm. diam., pedunculo ad 4 cm. longo; pedunculus et axes glabri; bracteae et bracteolae ad 1 mm. longae, subulatae, glabrae. *Flores* pedicello ad 7 mm. longo glabro. *Alabastrum* c. 2-3 mm. longum, cylindricum, apice inflatum. *Calyx* 0.5 mm. longus, subinteger, glaber. *Petala* viride-flava, c. 2 mm. longa, glabra. *Stamina* c. 1.5 mm. longa; antherae c. 0.3 mm. longae. *Ovarium* glabrum; stylus c. 2 mm. longus; stigma indistinctum. *Baccae* c. 8 × 7 mm., ellipsoideo-globosae, glabrae, semine unico; semen c. 7 × 6 mm., ellipsoideo-globosum, leviter rugosum.

Type: *Lovemore* 545 (SRGH, holotype).

NORTHERN RHODESIA. Southern Prov.: 3 km. N. of Chirundu Bridge, fl. 1.ii.1958, *Drummond* 5412 (K; PRE; SRGH).

SOUTHERN RHODESIA. Northern Div., Urungwe Distr., Rifa R. fl. 24.ii.1953, *Wild* 4099 (SRGH); 5 km. E. of Chirundu Bridge, fl. 5.ii.1958, *Drummond* 5487 (K; PRE; SRGH). Sebungwe Distr., Lubu R., fl. & fr. 12.i.1958, *Lovemore* 545 (SRGH). Darwin Distr., between Chiswiti Res. and Musengezi, fl. 28.i.1960, *Phipps* 2470 (SRGH). Western Div., Wankie Distr., fl. xii. 1954, *Levy* 1160 (E; K; PRE; SRGH).

Cyphostemma milleri Wild & Drummond, sp. nov.

C. anatomico (C.A. Sm.) Wild & Drummond affine sed foliis 5-foliolatis, fructibus glabris differt; *C. crassiusculo* (Bak.) Descoings affinis sed petalis glandulosis, fructibus glabris differt.

Herba scandens; caules ramique longitudinaliter striati, sparsissime pubescentes vel glabrescentes; cirrhi bifurcati, glabri. *Folia* digitata, 3-5-foliolata; petiolus ad 5 cm. longus, sparsissime capitato-glandulosis, apice acuta vel obtusa, basi cuneata, margine grosse serrata; pagina superior glabra; pagina inferior glabra sed nervis sparsissime glanduloso-pilosis; foliolum medianum ad 12 × 8 cm., rotundata; foliola lateralia ad 11 × 7 cm., late elliptica vel rotundata. *Stipulae* ad 8 mm. longae, anguste lanceolatae, falcatae, puberulae. *Cymae* compositae usque ad 16 cm. diam., pedunculo ad 5 cm. longo; pedunculus et axes sparse pubescentes; bracteae et bracteolae c. 1 mm. longae, subulatae, pubescentes. *Flores* pedicello ad 6 mm. longo pubescente et pilis capitato-glandulosis praedito. *Alabastrum* c. 2.5 mm. longum, cylindricum, ad medium constrictum. *Calyx* 0.5 mm. longus, subinteger, pubescens. *Petala* flavida, c. 2 mm. longa, pubescentia et apice pilis glandulosis praedita. Stamina 1.5 mm. longa; antherae 0.3 mm. longae. *Ovarium* glabrum; stylus c. 0.8 mm. longus; stigma indistinctum. *Baccae* flavidae, c. 9 × 7 mm., ellipsoidae, glabrae, semine unico; semen c. 7 × 5 mm. obovoideum, leviter rugosum.

Type: *Miller* 5778 (K; SRGH, holotype).

SOUTHERN RHODESIA. Matobo Distr., Besna Kobila, fr. v.1955, *O.B. Miller* 2851 (SRGH); Chesterfield Farm, in woodland, fl ii.1959, O.B. *Miller* 5778 (K; SRGH).

Cyphostemma montanum Wild & Drummond, sp. nov.

C. mannii (Bak.) Descoings affine sed alabastris c. 1.5 mm. longis multo minoribus, ramulis inflorescentiae sparse pubescentibus differt.

Herba scandens; caules ramique longitudinaliter striati, sparse pubescentes et pilis stipitato-glandulosis sparse praediti; cirrhi sparse pubescentes et pilis stipitato-glandulosis sparse praediti. *Folia* digitata, (3)5-foliolata; petiolus ad 5 cm. longus, sparse pubescens et pilis stipitato-glandulosis praeditus; foliola sessilia vel subsessilia; lamina elliptica vel obovata, apice acuminata, basi cuneata, margine crenato-serrata; pagina superior glabra; pagina inferior nervis sparse pubescens et pilis stipitato-glandulosis praedita; foliolum medianum ad 7 × 3 (4.5) cm., foliola lateralia ad 6 (7) × 2.3 (4) cm. *Stipulae* c. 7 mm. longae, lanceolatae, acuminatae, ± falcatae, pubescentes. *Cymae* compositae usque ad 4 (7) cm. diam., pedunculo ad 1.5 (8) cm. longo; pedunculus et axes pubescentes, interdum pilis stipitato-glandulosis sparse praediti; bracteae et bracteolae 1-2 mm. longae, filamentosae, pubescentes. *Flores* pedicello ad 2 mm. longo pubescente vel puberulo. *Alabastrum* ad 2 mm. longum, cylindricum, ad medium constrictum. *Calyx* 0.5 mm. longus, subinteger, puberulus. *Petala* c. 1.5 mm. longa, margine parce pubescentia. *Stamina* c. 1.3 mm. longa; antherae c. 0.2 mm. longae. *Ovarium* glabrum; stylus c. 1.2 mm. longus; apice minute bifidus. *Baccae* c. 7 × 5 mm., ellipsoidae, glabrae, semine unico; semen c. 6 × 4 mm., ellipsoideum, crista dorsale et cristis lateralibus 2 ornatis, rugosis praeditum.

Type: *Exell, Mendonça & Wild* 77 (BM; SRGH, holotype).

SOUTHERN RHODESIA. Eastern Div.: Nuza Plaeau, 1900 m., fl. ii.1935, *Gilliland* 1417 (BM; K). Inyanga, fl. & fr. 22.i.1942, *Hopkins* in GHS 8628 (SRGH). Vumba, Norseland, 1700 m., fl. 8.iii.1949, *Chase* 991 (BM; SRGH). Himalayas, Engwa, fl. ii.1955, *Exell, Mendonça & Wild* 77 (BM; SRGH). Melsetter, Chimanimani Mts., 1800 m., fr. 2.ii.1958, *Hall* 314 (SRGH); ibid, 1900 m., fl. 28.xii.1959, *Goodier & Phipps* 310 (SRGH).

Very nearly related to *C. mannii* but it is suggested that the long lageniform type of flower which is possessed by *C. mannii, C. lageniflorum* (Gilg & Brandt) Descoings, *C. kilimandscharicum* (Gilg) Descoings and several other species is an important diagnostic character in Cyphostemma and that consequently the relationship of *C. montanum* to *C. mannii* is not so close as would at first appear.

Cyphostemma richardsiae Wild & Drummond, sp. nov.

C. mildbraedii (Gilg & Brandt) Descoings affine sed pedicellis glandulosis, petalis glabris et fructibus glabris differt.

Herba perennis, prostrata; caules ramique longitudinaliter striati, pubescentes et pilis glandulosis praediti; ecirrhosi. *Folia* digitata, 3-5-foliolata; petiolus ad 3.5 cm. longus, pubescens et pilis glandulosis praeditus; foliola subsessilia aut petiolulis ad 1 cm. (ad. 2 cm. in mediano foliolo) longis, anguste obovata ad obovata, apice obtusa, basi cuneata, margine dentibus apiculatis serrato-crenata; pagina superior sparsissime pilosa; pagina inferior sparse pilosa sed nervis venisque pubescentibus et nervis principalibus pilis glandulosis praedita; foliolum medianum ad 16 × 8 cm.; foliola lateralia ad 9 × 4.5 cm. *Stipulae* ad 1 × 0.7 cm., persistentes, ovato-lanceolatae vel lanceolatae, acuminatae, pubescentes, margine pilis glandulosis sparse praediti. *Cymae* compositae, usque ad 9 cm. diam., pedunculo ad 7.5 cm. longo; pedunculus et axes pubescentes et pilis glandulosis praediti; bractae et bracteolae c. 1.5 mm. longae, subulatae, pubescentes. *Flores* pedicello ad 3.5 mm. longo, pubescente et pilis glandulosis praedito. *Alabastrum* ad 3.5 mm. longum, cylindricum, ad medium leviter constrictum. *Calyx* c. 0.3 mm. longus, subinteger, pubescens. *Petala* rubra et flavida c. 2.5 mm. longa, glabra sed apice pilo glanduloso unico interdum ornato. *Stamina* 1.75 mm. longa; antherae 0.5 mm. longae. *Ovarium* glabrum; stylus 1 mm. longus; stigma indistinctum. *Baccae* immaturae glabrae.

Type: *Richards* 3984 (K, holotype; SRGH).

NORTHERN RHODESIA. Northern Prov.: Abercorn Distr., Kasama near Sunsu turning, roadside, red sandy soil. 1700 m., fl. 9.i.1955, *Mrs. H. M. Richards* 3984 (K; SRGH):—prostrate, stem and petioles with stiff red hairs, stems red, flowers red and yellow; Abercorn, roadside, fl. 9.i.1955, *Bock* 217 (PRE; SRGH).

This species is allied to *C. kaniamae* (Mullenders ex Dewit) Descoings from which it differs in its glabrous ovary and fruit, the lack of glands on the calyx and in the absence of tendrils. From *C. mildbraedii* (Gilg & Brandt) Descoings it also differs in its glabrous fruit and in the presence of glands on the pedicels.

Cyphostemma robsonii Wild and Drummond, sp. nov.

C. amplexo (Bak.) Descoings affine sed foliolis subsessilis, pedicellis englandulosis differt.

Herba perennis, radicibus inflatis, scandens; caules ramique longitudinaliter striati, pubescentes vel glabrescentes; cirrhi bifurcati. *Folia* digitata, 3-5-foliolata; petiolus ad 5 cm. longus, pubescens; foliola subsessilia sed petiolulis medianis ad 1 cm. longis, ad 6 × 2 cm., oblanceolata vel anguste obovata, apice acuta, basi cuneata, margine dentibus apiculato-glandulosis serrato-crenata, utrinque sparse puberula. *Stipulae* ad 1 cm. longae, lanceolatae, acuminatae, margine minute ciliatae. *Cymae* compositae, usque ad 10 cm. diam., pedunculo ad 4 cm. longo glabro; bracteae et bracteolae ad 2 mm. longae, lanceolatae, glabrae. *Flores* pedicello ad 4 mm. longo glabro. Alabatsrum c. 2.5 mm. longum, cylindricum, ad medium constrictum. *Calyx* ad 0.4 mm. longum, subinteger, glabrum. *Petala* rubra, ad 2.3 mm. longa, glabra sed apice pilo glanduloso stipitato unico ornato. *Ovarium* glabrum, stylus c. 1.5 mm. longus; stigma subcapitatum. *Baccae* ignotae.

Type: *Robson* 1576 (K; SRGH, holo.).

TANGANYIKA. Songea Distr., about 1.5 km. S. of Gumbiro in *Brachystegia* woodland on sand, 910 m., fl. 24.i.1956, *Milne-Redhead & Taylor* 8522 (K):—climber, petals red, glands whitish.

NYASALAND. Central Province, N. of Chitala on Kasache road, 710 m., fl. 12.ii.1959, *Robson* 1576 (K; SRGH):—climbing, flowers red.

Cyphostemma rotundistipulatum Wild & Drummond, sp. nov.

C. bororensi (Klotzsch) Descoings affine sed foliis semper 3-foliolatis, stipulis multo majoribus rotundatis, calycibus pedicellisque pubescentibus differt.

Herba scandens; caules ramique longitudinaliter striati, sparse pubescentes deinde glabrescentes; cirrhi bifurcati, glabri. *Folia* digitata, 3-foliolata; petiolus ad 4 cm. longus, sparse pubescens demum glabrescens; foliola membranacea, subsessilia aut petiolulis ad c. 7 mm. in mediano foliolo, apice acuta vel acuminata, margine apiculato-crenata;

pagina superior glabra praeter nervum medium atque nervos majores laterales puberulos; pagina inferior glabra; foliolum medianum ad 9.5 × 3.5 cm., anguste ovatum, basi cuneatum; foliola lateralia ad 7 × 3 cm., ovata, basi obtuse asymmetrica. *Stipulae* ad 2.5 cm. diam., persistentes, circulares vel oblatae, apice obtusae, basi leviter cordatae, margine sparse crenatae, glabrae. *Cymae* compositae usque ad 8 cm. diam., pedunculo ad 4 cm. longo; pedunculus et axes sparse pubescentes; bracteae et bracteolae c. 1 mm. longae, subulatae, pubescentes. *Flores* pedicello c. 4 mm. longo pubescente et plerumque pilis glandulosis subsessilibus praedito. *Alabastrum* ad 2.5 cm. longum, cylindricum, ad medium constrictum. *Calyx* 0.5 mm. longus, subinteger, pubescens et dense glandulosus. *Petala* rubra, c. 2.2 mm. longa, glabra. *Stamina* c. 1.3 mm. longa; antherae c. 0.3 mm. longae. *Ovarium* glabrum; stylus 1.5 mm. longus; stigma indistinctum. *Baccae* rubra, c. 8 × 6 mm., subglobosae, glabrae, semine unico; semen c. 5 × 4 mm., obovoideum, ± laeve.

Type: *Richards* 4068 (K, holotype).

NORTHERN RHODESIA. Northern Prov.: Abercorn Distr., Chilongowelo, below escarpment, 1630 m., open bush, loamy soil, fl. 4.iii.1952, *Richards* 909 (K):—climbing, stem red, flowers reddish. Sunsu, *Brachystegia* woodland, 1600 m., fl. 8.i.1955, *Bock* 175 (PRE; SRGH):—trailing. Old Rd. to Stembewe, woodland, 1600 m., fl. 14.i.1955, *Richards* 4068 (K):—flowers brown and yellow. Old Isanya Rd., 1600 m., fl. 18.i.1955, *Richards* 4147 (K):—climbing, flowers green and red. Rd. to Kali Dambo, 1600 m., fr. 4.iv.1955, *Richards* 5281 (K).

Cyphostemma septemfoliolatum Wild & Drummond, sp. nov.

C. chloroleuco (Welw. ex Bak.) Descoings affine sed foliis 7-foliolatis, foliolis elongatis angustis alabastris eglandulosis differt.

Herba erecta, c. 0.8 m. alta, radicibus inflatis; caules ramique longitudinaliter striati, pubescentes, ecirrhosi. *Folia* digitata, 7-9-foliolata; petiolus ad 4 cm. longus, pubescens; foliola subsessilia aut petiolulis ad 2 cm. longis, ad 26 × 4 cm., lineari-elliptica vel angustissime elliptica, apice acuminata, basi angustissime cuneata, margine serrata; pagina superior glabra sed nervo medio puberulis; pagina inferior albido-villosa vel tomentosa sed nervis venisque reticulatis ± glabrescentibus brunneis. *Stipulae* ad 1 × 0.4 cm., oblongo-lanceolatae, apice acuminatae, dense pubescentes. *Cymae* compositae, usque ad 20 cm. diam., pedunculo ad 8 cm. longo; pedunculus et axes pubescentes; bracteae et bracteolae c. 1-2 mm. longae, subulatae, pubescentes. *Flores* pedicello ad 3 mm. longo, pubescentes. *Alabastrum* c. 1.75 mm. longum, cylindricum, ad medium leviter constrictum. *Calyx* c. 0.25 mm. longus, subinteger, pubescens. *Petala* flavida vel rubra, c. 1.7 mm. longa, glabra. *Stamina* c. 0.7 mm. longa; antherae 0.4 mm. longae. *Ovarium* glabrum; stylus c. 1 mm. longus; stigma subcapitatum. *Baccae* immature glabrae.

Type: *Richards* 2295 (K, holotype).

TANGANYIKA. Rungwe Distr., Kyimbila, Mulinda Forest, 800 m., fl. 9.i.1912, *Stolz* 1822 (K).

NORTHERN RHODESIA. Northern Province: Abercorn Distr., Chilongowelo, under trees in good loam soil, 1700 m., fl. *Richards* 2295 (K):—flowers yellow-green; Kalambo Falls, in woodland, 1700 m., fl. 6.i.1955, *Richards* 3925 (K; SRGH). Kasama Distr., Mungwi, fl. 19.xi.1960, *Robinson* 4088 (SRGH). Central Province: Serenje Distr., Kanona Rest House, in *Brachystegia spiciformis, B. longifolia, Parinari curatellifolia, Pterocarpus angolensis* woodland, fl. 30.xi.1952, *F. White* 3802 (FHO).

Cyphostemma cirrhosum (Thunb.) Descoings in Not. Syst. **16**: 120.

Type: Cape Province, Uitenhage, *Thunberg* s.n. (UPS, holo.; SRGH, photo).

Vitis cirrhosa Thunb., Prodr. Pl. Cap **1**: 44 (1794). Type as above.

Cissus cirrhosa (Thunb.) Willd. in L., Sp. Pl. ed. 4, **1**: 657 (1798).

Type as above.

Subsp. **cirrhosum**

Stems eglandular. Leaflets sessile.

Cape Province and Natal.

Subsp. **transvaalense** (Szyszyl.) Wild & Drummond, comb. nov.

Vitis cirrhosa var. *transvaalensis* Szyszyl., Polyp. Thalam. Rehmann.: 45 (1888). Type: Transvaal, *Rehmann* 4578 (K).

Cissus cirrhosa var. *transvaalensis* (Szyszyl.) Burtt Davy & Pott-Leendertz in Ann. Transv. Mus. **3**: 121, 151 (1912). Type as above.

Cissus sandersonii var. *transvaalensis* (Szyszyl.) C.A. Sm. in Burtt Davy, F.P.F.T. **2**: xx, 476 (1932). Type as above.

Stems eglandular. Leaflets petiolate.

Cape Province, Natal, Transvaal, S.W. Africa and Bechuanaland Protectorate (Kwebe Hills, fl. ii.1897, *F. D. & E. J. Lugard* 187 (K)).

Subsp. **rhodesicum** Wild & Drummond, subsp. nov.

Ramuli dense pubescentes et pilis glandulosis ± dense praediti.

Type: *Rogers* 5775 (K; SRGH, holo.).

SOUTHERN RHODESIA. Northern Division: Between Umvukwes and Banket, fr. 23.iv.1948, *Rodin* 4394 (K; PRE). Central Division: Salisbury Kopje, fl. xi.1908, *Rand* 1363 (BM). Salisbury, fl. ii.1912, *Rogers* 5775 (K; SRGH); ibid., fl. ii.1920, *Eyles* 2061 (SRGH); ibid., Lochinvar, fl. & fr. 20.i.1946, *Wild* 717 (K; SRGH); ibid., Twentydales, fl. 18.xii.1951, *Wild* 3706 (SRGH); ibid., Prince Edward Dam, fl. 8.i.1952, *Wild* 3735 (SRGH); ibid., fl. 21.ii.1957, *Phipps* 534 (SRGH). Eastern Division: Inyanga, fl. 22.i.1942, *Hopkins* in GHS 8628A (SRGH).

NYASALAND. Central Province: Dedza, fl. 7.i.1961, *Chapman* 1112 (SRGH).

This species of *Cyphostemma* is unusual in the African species in showing such a wide range of variation. The three principal variants seem to fall into fairly well defined geographical areas and so they are here considered as subspecies. The presence of glands on the various parts of the inflorescence in *Cyphostemma* is often of specific importance, but this does not seem to apply when the glands are on vegetative parts as in subsp. *rhodesicum*.

Cyphostemma simulans (C.A. Sm.) Wild & Drummond, comb. nov.

Cissus simulans C.A. Sm. in Burtt Davy, Fl. Pl. Ferns Transv. & Swazil. **2**: xx, 476 (1932).

Type: Transvaal, White River, Dec. 1919, *Rogers* 25007 (PRE, holo.).

Cyphostemma anatomicum (C.A. Sm.) Wild & Drummond, comb. nov.

Cissus anatomica C.A. Sm. in Burtt Davy, Fl. Pl. Ferns Transv. & Swazil. **2**: xx, 476 (1932).

Type: Transvaal, Pietersburg Distr., The Downs, *Junod* 4216 (PRE, holo.).

Cyphostemma puberulum (C.A. Sm.) Wild & Drummond, comb. nov.

Cissus puberula C.A. Sm. in Burtt Davy, Fl. Pl. Ferns Transv. & Swazil. **2**: xx, 476 (1932).

Cissus lanigera var. *sosong* Planch. in A. & C.DC., Mon. Phan. **5**, **2**: 600 (1887) "sosang".—Gilg & Brandt in Engl., Bot. Jahrb. **46**: 542 (1912).

Type: Bechuanaland Prot., Bamangwato Country, *Holub* (K, holo.).

Cyphostemma graniticum (Wild & Drummond) Wild & Drummond, comb. nov.

Cissus granitica Wild & Drummond in Kirkia **1**: 11 (1960).

Type: S. Rhodesia, Inyanga, Inyangombe Falls, *Wild* 4883 (BRLU; K; LISC; PRE; SRGH, holo.).

Cyphostemma vanmeelii (Lawalrée) Wild & Drummond, comb. nov.

Cissus vanmeelii Lawalrée in Bull. Jard. Bot. Brux. **19**: 219 (1949). —Dewit, Fl. Congo Belge **9**: 493 (1960).

Type: Congo, Vua, March 1947, *Van Meel* 1075 (BR, holo.).

Cissus stipulaceoides Dewit in Bull. Jard. Bot. Brux. **29**: 494 (1959); Fl. Congo Belge **9**: 494 (1960). Type: Congo, Elisabethville, *Schmitz* 1240 (BR, holo.).

Cyphostemma stipulaceoides (Dewit) Descoings in Not. Syst. **16**: 125 (1960).

Cyphostemma wittei (Staner) Wild & Drummond, comb. nov.

Cissus wittei Staner in De Wild. & Staner, Contr. Fl. Katanga, Suppl. 4: 49 (1932).—Dewit, Fl. Congo Belge **9**: 470, fig. 12A (1960).

Type: Congo, Katanga, Lukafu, *G. de Witte* 43 (BR, holo.).

Cissus crusei Wild & Drummond, sp. nov.

C. aralioidi (Welw. ex Bak.) Planch. et *C. cussonioidi* Schinz affinis, ab hac 5-7 glabris foliolis et minoribus baccis, ab illa erectu habitu distinguitur.

Herba erecta, ecirrhosa, omnino glaber, ad 40 cm. alta, caule discurrente non ramoso longitudinaliter sulcato. *Folia* digitata 5 (7) - foliolata, petiolo 3-9.5 cm. longo; foliola ad 13.5 × 3.5 cm., subsessilia, anguste obovata, apice apiculata, basi anguste cuneata, margine serrata (interdum irregulariter pinnatifida). *Stipulae* 6 cm. longae, ovatae. *Cymae* axillares ad 3 cm. diam., pauciflorae, pedunculo 2 (3) cm. longo; bractae et bracteolae 0.5-2 mm. longae, ovatae. *Flores* pedicello 3-4 mm. longo. *Alabastrum* 2.5 × 1.5 mm., conicum. *Calyx* ad 1 mm. altus, subinteger. *Petala* ad 2 mm. longa, rubroviridia. *Stamina* 1.75 mm. longa; antherae 0.75 mm. longae. *Ovarium* 0.5 mm. longum; stylus 1 mm. longus; stigma leviter capitatum. *Baccae* 9 × 8 mm., globosae, semine unico; semen 5 × 4 mm., laeve.

Type: *Cruse* 464 (K, holotype).

NORTHERN RHODESIA. Western Prov.: Mwinilunga Distr., just south of Matonchi Farm, on termite hill, fl. 13.xii.1937, *Milne-Redhead* 3651 (K):—erect perennial with napiform woody rootstock, stem zig-zag, strongly angled and winged, green, petiole with many wings and grooves, leaflets usually 5, lateral pair lobed, deep green somewhat rugose above, green with strongly raised nerves below, inflorescences several, petals reddish-purple, greenish yellow at base, lobes of disk, filament and style creamy; Mufulira, *Brachystegia* woodland, fl. 30.xii.1948, *Cruse* 464 (K):—erect, thick fleshy grooved stem, flower green to pinkish. Central Prov.: near Mumbwa, fr. 1911, *Macaulay* 718 (K); fl. 1912, *Macaulay* 1072 (K); 9.5 km. E. of Lusaka, under trees in stream valley, fl. 16.xii.1955, *King* 248 (K):—erect herb with winged stem to 45 cm. high, flowers tinged with red, rootstock fairly large.

Cissus fanshawei Wild & Drummond, sp. nov.

C. aphyllanthae Gilg et *C. cornifoliae* (Bak.) Planch. affinis sed laxioribus, amphioribusque, glabris, inflorescentiis et foliis glabris differt.

Liana lignosa, cirrhosa, omnino glaber, caule leviter longitudinaliter striato cylindrico. *Folia* simplicia, petiole ad 3 cm. longo; lamina 7 × 6 cm., late ovata, apice apiculata, basi cordata, margine serrata. *Stipulae* 2.5 × 1.5 mm., oblongae. *Cymae* ad 17 × 8 cm., multiramosae, pedunculo 0.5-3.5 cm.; bracteae et bracteolae 2.5 × 2.5 mm., circulares, basi auriculatae, minute ciliatae. *Flores* pedicello 2.5-4 mm. longo. *Alabastrum* 1.5-1.75 × 1.5 mm., conicum. *Calyx* 0.25-0.5 mm. altus, subinteger. *Petala* ad 1.5 mm. longa, flavoviridia. *Stamina* 1.75 mm. longa; antherae 0.5 mm. longae. *Ovarium* glabrum; stylus 1 mm. longus; stigma subcapitatum. *Baccae* juveniles glabrae.

Type: *Fanshawe* 1578 (EAH; FHO; K, holotype; NDO; SRGH).

NORTHERN RHODESIA. Northern Prov.: Kawambwa, ant-hills, fl. 25.viii.1957, *Fanshawe* 3634 (K; NDO):—woody climber, leafless at flowering, flowers greeny yellow. Western Prov.: Ndola, ant-hills, fl. 29.ix.1954, *Fanshawe* 1578 (EAH; FHO; K; NDO; SRGH):—supple, brown, scaly vine, leafless, flowers in branched flat-topped panicles, yellow; Kitwe, ant-hills, st. 15.iii.1957, *Fanshawe* 3048 (NDO):—mature leaves of a woody liane, cordate, serrate, minutely reticulate below with leaf-opposed tendrils.

Cissus faucicola Wild & Drummond, sp. nov.

C. aralioidi (Welw. ex Bak.) Planch. et *C. crusei* Wild & Drummond affinis, ab hac scandente, habitu ab illa minoribus, floribus distinguitur.

Herba scandens, omnino glaber, cirrhis bifurcatis. *Folia* digitata, (3-) 5 foliolata, petiolo ad 4 (-7.5) cm. longo; foliola ad 9 × 2.8 cm., subsessilia vel breviter petiolata, elliptica, apice acuminata, basi anguste cuneata, margine setiformibus dentibus ad 1 mm. longis serrata; florentes rami folia simplicia reducta cymas opposita gerentes. *Stipulae* 4 × 2 mm., anguste ovatae. *Cymae* congestae, pauciflorae, pedunculo 5 mm. longo; bracteae et bracteolae 0.5-2 mm. longae. *Flores* pedicello 2.5 mm. longo. *Alabastrum* 2 × 1.5 mm., conicum. *Calyx* ad 1 mm. altus, subinteger vel obscure 4-lobatus. *Petala* flavoviridia. *Stamina* 1.25 mm. longa; antherae 0.5 mm. longae. *Ovarium* glabrum, stylus 1 mm. longus; stigma subcapitatum. *Baccae* juveniles glabrae.

Type: *Richards* 7343 (K, holotype; SRGH).

TANGANYIKA. Southern Highlands Prov.: Kyimbila Distr., fl. 17.i.1911, *Stolz* 546 (K). Njombe, 14.xii.1931, *Lynes* D. g.152 (K):—soft twiner; Njombe Distr., Mwakete, edge of wood, 2100 m., fl. 16.i.1957, *Richards* 7835 (K):—climbing high over trees, stem woody, leaves shiny, flowers yellow. Southern Prov.: Songea Distr., Lupembe Hill, at edge of upland rain forest 1860 m., fl. 11.i.1956, *Milne-Redhead & Taylor* 8200 (K):—strong-growing climber, leaves unifoliolate or 3-foliolate, stems green tinged purplish, leaves deep green above with sunken nerves, petals white with reddish tips, calyx reddish, disk cream, often tinged pink, style white.

NORTHERN RHODESIA. Northern Prov.: Abercorn Distr., Lake Chila by inlet of Lucheche, among boulders in shade, 1525 m., fl. 29.xii.1954, *Richards* 3776 (K):—climbing, flowers pale yellow; Abercorn Distr., Chilongowelo, in deep gorge, 1440 m., fl. 24.xii.1956, *Richards* 7343 (K; SRGH):—climbing, leaves shiny, flowers yellow. Lake Mweru, chipya woodland, fl. 14.xi.1957, *Fanshawe* 3968 (K; NDO):—flowers yellow-green. Kasama Distr., Luombe R. below Chishimba Falls, riparian woodland, fl. 9.i.1961, *Bands* 643 (SRGH).

NYASALAND. Northern Prov.: Karonga Distr., Misuku Hills, forest, 1500 m., 11.i.1959, *Richards* 10602 (K):—flowers yellow; ibid., 1650 m., 12.i.1959, *Richards* 10613 (K; SRGH):—flowers yellow and brown. Southern Prov.: above Neno, Kirk Range, patch of closed forest in gully on south-facing slope, fl. 8.xii.1960, *Chapman* 1075 (K; SRGH):—creeper with trifoliolate leaves and greenish flowers.

Several sheets (*Richards* 7835, *Richards* 10602, *Milne-Redhead & Taylor* 8200) have leaves with markedly scabrid petioles and midrib and nerves beneath, but they do not appear to be specifically distinct.

Zimmerman s.n. (EAH) labelled "Cissus alata sp.n." presumably from the Eastern Usambaras may well belong to this species and would consequently greatly extend the range of the species.

NOTES ON THE GENERA *CELOSIA* L. AND *HERMBSTAEDTIA* REICHB. (AMARANTHACEAE) OCCURRING IN SOUTHERN AFRICA

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INTRODUCTION

When I was entrusted with the naming of the incoming material of Amaranthaceae in the National Herbarium, Pretoria, difficulties were repeatedly encountered with specimens referable to the genera *Hermbstaedtia* Reichb. and *Celosia* L. It was, therefore, decided to study these genera more closely. It soon became apparent that several taxa are extremely variable and, accordingly, it seemed desirable to study the largest possible number of specimens. Needless to say, this variability has been responsible for the fairly large number of "species" described, most of which, in my opinion, do not even deserve the rank of varieties.

In addition, there has been a great deal of confusion between, and incorrect interpretation of some species by different workers in the various regional floras and in other publications. As an example I quote Schinz [Vtljschr. Naturf. Ges. Zürich **56**: 253 (1911)]: "How complicated things are is also demonstrated by the fact that, e.g., Baker and Clarke (in Fl. Trop. Afr.) united *Celosia recurva* Burch. with *Hermbstaedtia caffra* Moq., whereas Cooke and Wright (in Fl. Cap.) absolutely disagree with them and distinguished between *C. recurva* and *H. caffra*, but consider the former to be identical with *Celosia odorata* Burch. (= *Hermbstaedtia odorata* T. Cooke), in spite of these authors having studied the same original specimens!"

A number of specimens were sent to our officer stationed at Kew (Mr. B. de Winter) who compared some of them, but sent the majority to the late Prof. K. Suessenguth for his opinion. These specimens were returned after they had been named by Prof. Suessenguth, but I cannot accept Suessenguth's specific concepts, and that is why it seems necessary to publish my personal views.

A study of a large number of herbarium sheets and of many live specimens in the field, combined with observations of several species grown in the garden of the Division of Botany, Pretoria, enabled me to obtain some insight into the variability of many characters, including the effect of the environment and the seasonal climatic variations upon the growth form. It soon became apparent that the variation of several characters which had in the past often been used as "key characters" to distinguish taxa or groups of taxa, renders the taxonomic value of these characters very doubtful if not useless. There are, however, a few characters sufficiently constant to base a classification into well defined taxa upon them, but the number of described "species" must drastically be reduced. This conclusion was reached several years ago, but for various reasons this paper was left lying. In the meantime observations of live specimens in the field and in cultivation were continued, whilst many more herbarium specimens came to hand. This additional information not only strengthened my previous conclusions but also gradually convinced me that certain forms which I had previously considered to be perhaps worthy of a varietal status are most probably nothing but juvenile stages, luxuriant forms, seasonal variants or grazed (and regenerated) specimens. When I studied the genera again recently I reconsidered my previous findings and rewrote several parts of my manuscript. I gratefully acknowledge the assistance of Mr. P. E. Haster who examined and named a number of recent gatherings and put my keys to the test.

DELIMITATION OF THE GENERA *CELOSIA* AND *HERMBSTAEDTIA*

There has been considerable disagreement in the past as regards the delimitations of the genera *Celosia* and *Hermbstaedtia*, so that several species have been transferred from the one genus to the other and vice versa.

In the original conception of Reichenbach and of Moquin-Tandon (cf. DC., Prodr. **13**, 2, 246) *Hermbstaedtia* possesses bifid pseudostaminodes (processes of the staminal tube) alternating with the stamens ("Staminodia interjecta, elongata, bifida") and a short style ("Stylus brevis aut nullus"), whereas *Celosia* (Moq., op cit.: 238) possesses no pseudostaminodes at all and either a long or a short style. In addition, *Celosia* was described as having a short staminal tube ("Stamina 5, in tubum brevem coalita") and usually short free filaments ("Filamentorum pars libera subulata, saepius brevis").

Later, however, Schinz (Verhandl. Bot. Ver. Brandenb. **31**, 1890: 209-210) described a few species from S.W. Africa which he placed in *Hermbstaedtia*, although they do not possess pseudostaminodes interjected between the anthers as in the original diagnosis of the genus (*H. linearis*, *H. argenteiformis* and *H. scabra*). The staminal tube in these three species is lobed at the apex, each lobe bearing an anther on a very short apical filament or in a notch (cf. Fig. 1). These species were subsequently transferred to *Celosia* (as a special section or subgenus *Pseudohermbstaedtia*) by Schinz in Engler-Prantl, Natürl. Pflanzenfam. **1**, 3, 1a (1893), his interpretation being that pseudostaminodes are lacking and the lobes of the staminal tube are only "broad filaments". This interpretation was followed by Lopriore, in Engl., Bot. Jahrb. **30**: 102 (1901), who placed the species under discussion in two separate subdivisions of *Celosia*, viz., *Pseudohermbstaedtia* Schinz (comprising the forms with the anthers borne apically on rounded lobes of the staminal tube) and *Gomphrohermbstaedtia* Lopr. (comprising the forms with the anthers borne in notches of the lobes of the staminal tube), as distinct from all other species of *Celosia* which were placed in the subgenus (or section) *Eucelosia* Schinz. Baker and Clarke on the other hand (in Dyer, Fl. Trop. Afr. **4**, 1: 25), referred the species in question to *Hermbstaedtia* again, assuming that a "broad filament" (= lobe or the staminal tube) is "a linear filament fused on either side with half a sterile filament" (= pseudostaminode). This conception was followed by Cooke and Wright (in Dyer, Fl. Cap. **5**, 1: 404-405, cf. their generic diagnosis), by Burtt-Davy in his Man. Flow. Pl. Transv. **1**: 179 (1926), and by Phillips in his Gen. S. Afr. Flow. Pl., ed. 2: 274, 275 (1951). Schinz, in his subsequent publications and in the second edition of the "Pflanzenfamilien" (Vol. 16c, 1933) maintained his point of view and excluded all species without bifurcate pseudostaminodes between the anthers from *Hermbstaedtia*. He recognized *Gomphrohermbstaedtia* Lopr. as a subgenus of *Celosia* next to his subgenus *Pseudohermbstaedtia*.

The forms referred by Schinz to these two subgenera of *Celosia* are very similar in appearance to species of *Hermbstaedtia* and one might wonder if the genus *Hermbstaedtia* had not better be included in *Celosia*. For the present, to retain the *status quo*, I follow Schinz's treatment, because *Hermbstaedtia*, in its limited sense, represents a perfectly homogeneous group of species which can, technically, always clearly be distinguished from Celosia, sensu lato, by the presence of the pseudostaminodes between the anthers, whereas the subgenera "*Eucelosia*" Schinz and *Pseudohermbstaedtia* are not so clearly separable.

For generic diagnoses the reader is referred to Schinz (1933, l.c.).

The genus *Celosia* is divided by Schinz into three subgenera, as was mentioned above, according to the type of staminal tube and the insertion of the anthers, as follows (see also Fig. 1).

(a) *Eucelosia* Schinz (= *Celosia* s.s., as treated in Fl. Trop. Afr., Fl. Cap. and in Phillips, Gen. S. Afr. Flow. Pl.).—Filaments distinct, more or less filiform or subulate; style varying from long to short; inflorescence either a terminal, simple, dense, continuous spike, or flowers in dense cymes or glomerules, sometimes in lax spikes or small panicles, which are almost invariably arranged in leafless, usually narrow compound panicles or (usually interrupted) pseudospikes. Seeds either smooth (or nearly so) and shiny, or finely tuberculate or areolate and dull.

(b) *Pseudohermbstaedtia* Schinz.—Staminal tube with five, usually ovate or oblong rounded lobes, each of which bears a short apical filament reduced to a mucro; anthers almost sessile; style long, often exserted; inflorescence a terminal, usually dense, continuous spike (rarely more or less interrupted at the base), very rarely more or less branched at the base; seeds smooth, shiny.

(c) *Gomphrohermbstaedtia* Lopr.—Staminal tube with five, often oblong emarginate lobes, each of which bears an almost sessile anther in a notch, the lateral tips of the lobes overtopping the filament mucro; other characters as in *Pseudohermbstaedtia*.

The distinction between the last two subgenera has never been a very sharp one. C. *scabra*, for instance, has been placed in *Gomphrohermbstaedtia* by Baker and Clarke, whereas Schinz referred it to his section *Pseudohermbstaedtia*. I have found that both types of staminal attachment may occur on the same plant, even in one staminal tube (cf. Fig. 2), so that these two subgenera cannot be separated and all species of *Celosia* with broad anther-bearing lobes of the staminal tube have to be placed in one group which should bear the name *Pseudohermbstaedtia*.

The subgenus "*Eucelosia*" is divided by Schinz (1934) into three sections:

1. *Lestibudesia* (Pet.-Thou.) Moq. (incl. sect. *Celosiella* Moq.)—Style short; top of ovary not thickened.
2. *Celosiastrum* Moq.—Style long, top of ovary not thickened.
3. *Lageniformes* Schinz.—Style short, ovary lageniform with thickened, spongy top.

Schinz's nomenclature cannot be maintained under the present Code of Nomenclature and an emended system is given below (see p. 10). Baker and Clarke (in Fl. Trop. Afr.) divided *Celosia* into two sections viz., *Lestibudesia* and *Eu-Celosia*, which are not identical with *Lestibudesia* Moq. and with *Eucelosia* Schinz, because, for instance, *C. argentea* L., placed by Moquin-Tandon in *Celosiastrum* and not in *Lestibudesia*, is placed by Baker and Clarke in *Lestibudesia*, whereas *C. populifolia* Moq., placed by Moquin-Tandon in *Celosiella* (= *Lestibudesia* Schinz pro parte) appears under *Eu-Celosia* in Fl. Trop. Afr. This may add to the confusion and it is therefore recommended to follow Schinz's nomenclature, as emended below.

The genus *Hermbstaedtia* sens. strict. has never been divided into sections.

TAXONOMIC VALUE OF SOME CHARACTERS

Of the characters that have often been used in keys and also as distinctive features in descriptions of "new" species of *Celosia* and *Hermbstaedtia*, such as the number of style branches, the number of seeds per capsule, the length of the perianth, the relative lengths of perianth, staminal tube, anthers, pseudostaminodes, etc., the majority is extremely variable. The taxonomic value of these characters depends entirely upon their constancy or near-constancy and, to obtain some idea of the variability, a fairly large number of flowers of every specimen was dissected (usually about 10, unless the material was too scanty). Some characters proved to be rather variable, so that specific distinctions (as used in keys) based upon, e.g., the number of style-branches only, are useless. Sometimes a character is fairly constant in one or a few species and variable in others.

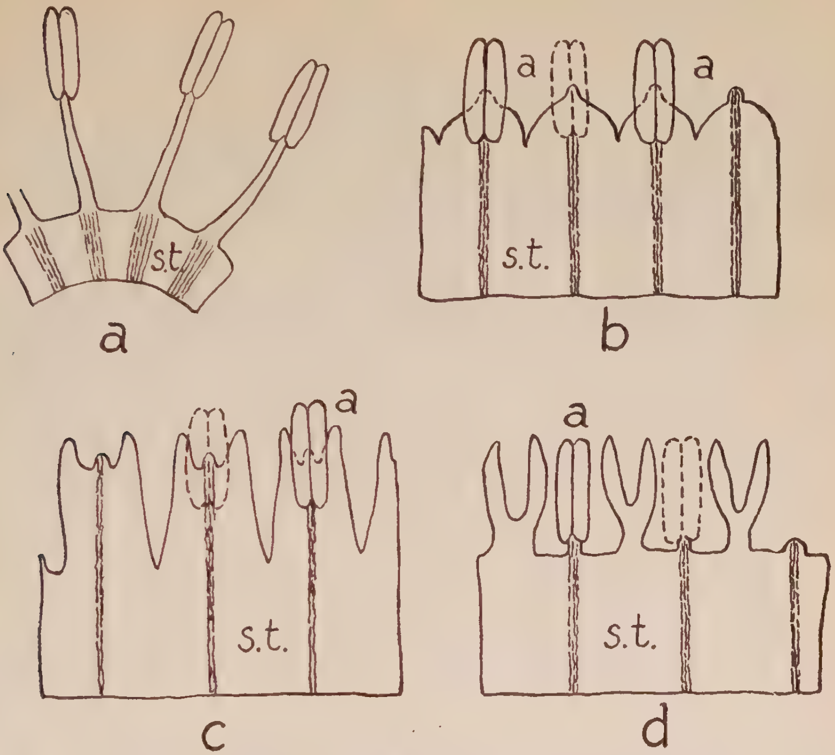

Fig. 1.—Parts of androecium of *Celosia* and of *Hermbstaedtia* (semi-diagrammatic). st. = staminal tube, a. = anther.

a. *Celosia* subgenus *Celosia.*

b. and c. *Celosia* subgenus *Pseudohermbstaedtia* Schinz: 2. represents the subgenus *Pseudohermbstaedtia* sensu Lopriore and 3 the subgenus *Gomphrohermbstaedtia* Lopr.

d. *Hermbstaedtia.*

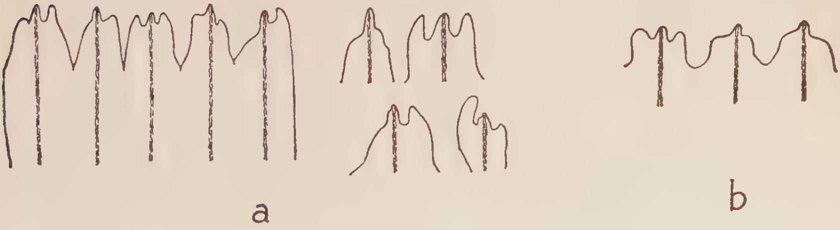

Fig. 2.—Parts of staminal tubes of (left): *Schoenfelder* S 409 (*Celosia scabra* (Schinz) Schinz) and (right): *Theiler* H. 10336 (= *C. linearis* Schinz).

The following characters were thoroughly examined:

(a) *General habit and shape of the inflorescence*

The species which grow in extreme environments, such as the Namib desert species *Celosia spathulifolia*, the Namaqualand species *Hermbstaedtia glauca* and the costal bush species *Hermbstaedtia caffra*, are subject to varying but seasonally fairly constant climatic and edaphic environmental conditions and do not show a great deal of variability.

The species which occur in regions with a marked dry and wet season, on the other hand, are subject to changing environmental factors. The annuals among them develop from seed after the first good rain, but if a period of drought follows the first rains, the young plants are arrested, which results in stunted growth, smaller and shorter inflorescences, whereas continued rains enable them to develop into luxuriant forms with large inflorescences. Young plants soon produce young inflorescences which are often subglobose, whereas older plants have well-developed elongate inflorescences.

Several species are eagerly grazed by cattle and by game. Mr. O. A. Leistner, of the Botanical Survey, Division of Botany, Pretoria, told me that in the Kalahari Gemsbok National Park he could hardly find a specimen of *Celosia linearis* worth collecting as most plants were eaten off, so that they regenerate by short lateral shoots from the base and produce ascending stems with short inflorescences and, because the regeneration takes place later in the season when the wet spells are already over and the temperature has already dropped, they may also become stunted or arrested. The general habit is so much affected by the prevailing conditions that it is not easy to realize that all these growth forms belong to one taxon. The type gathering of *Celosia linearis* consists of young plants, apparently vigorously growing when they were collected and already flowering with young, subglobose inflorescences. The type gatherings of other described species (*C. namaensis, C. welwitschii, C. fleckii*, etc.) consist of well-developed plants with long spikes. I collected a stunted form of *C. linearis* in Sekukuniland in midwinter which had obviously been grazed before and produced ascending stems up to about 15 cm. long with small leaves and short capituliform spikes 1-3 cm. long. These plants are indistinguishable from "*C. humilis* Suesseng." which, incidentally, was also collected during the unfavourable season (in September!). Seeds collected from these Sekukuniland plants were successfully grown in the garden of the Division of Botany, Pretoria and developed into vigorous plants, with erect, 70-90 cm. long stems, bearing long leaves up to 7 cm. long and elongate spikes 20-30 cm. long. These plants are indistinguishable from the forms described as *C. namaensis, C. fleckii* and *C. welwitschii*.

Perennial species such as *Hermbstaedtia odorata* are not so much dependent on the rainfall but in dry years are also to some extent arrested and stunted. They are also grazed and regenerate as spreading low forms with shorter inflorescences.

When the stems die off in the dry season the (usually pink to reddish) colour of the petals bleaches to a pale straw-colour or a scarious white, often somewhat blackened through weathering and the action of moulds. Gatherings of such old stems have been described as species (*Hermbstaedtia transvaalensis* !).

It goes without saying that neither the general habit (erect and tall, or many-stemmed and spreading), nor the size of leaves and inflorescences is sufficiently constant to be characteristic of any of the species, except in such forms as *Celosia spathulifolia, Hermbstaedtia caffra* and *H. glauca.* Specific characters in most of the other species can therefore only be found in the floral characters, in the degree of pubescence and in the characters of fruit and seed.

(b) *Leaf-shape and pubescence*

In several species the leaf shape is rather variable (e.g., in *Hermbstaedtia odorata* from linear, recurved, to flat, obovate), so that this character by itself is of little value, except in *C. schaeferi,* which has broader ovate to orbicular leaves on long petioles unlike all other species of the same subgenus.

The pubescence is variable in several species (*H. odorata*), but in some cases the pubescence or lack of pubescence is characteristic: *H. caffra* is completely glabrous in all its parts, *C. argenteiformis* is almost invariably quite glabrous, *C. scabra* is usually distinctly hairy and scabrid, etc. The pubescence of the rhachis of the spike of *H. odorata* is, among other things, very useful to distinguish this species from *H. caffra* (which has a glabrous rhachis).

A character mentioned by Burtt-Davy in his description of "*Hermbstaedtia rogersii*" is the papillose ovaries, but Schinz had already described *Celosia scabra* as having papillose ovaries, so that this character did not appear useful to distinguish *H. rogersii* from *C. scabra* (as Burtt-Davy's key seems to suggest). However, this character is hardly present in "*H. rogersii*" and in fact *C. scabra* is the only one with a manifestly papillose ovary, which is the best character to distinguish this species from the rest of the taxa in the subgenus *Pseudohermbstaedtia,* in which the ovary and capsule are glabrous or at most very minutely papillose.

(c) *Dimensions and shape of floral parts*

The tepals, staminal tube, styles and bracts are persistent till the capsules have opened and continue growing after pollination, so that in one inflorescence the lowermost flowers are always the largest. Young inflorescences of *Celosia* subgenus *Pseudohermbstaedtia* tend to be more or less "tufted" or "comose" at the apex because the bracts overtop the young flowers, whereas in older inflorescences this character is less conspicuous. The shape of the lobes of the staminal tube in *Pseudohermbstaedtia* is not always a reliable character, as was pointed out on

p. 147. Still, it is convenient to describe a staminal tube as being of the "*Pseudohermbstaedtia*-type" sensu Lopriore (i.e., with rounded lobes bearing the anthers on apical mucros, see Fig. 1, b), or of the "*Gomphrohermbstaedtia*-type" (i.e., with the anthers in notches of the lobes, see Fig 1, c). These types of staminal tubes will be referred to as "P-type" and "G-type" respectively. Some species have consistently one type of staminal tube (*C. argenteiformis* always has the G-type, C. *spathulifolia* always the P-type), and this character is, therefore, useful in some instances.

The length of the staminal tube increases as the flower grows older. As far as I can conclude from the available material, only the relation of the length of the lobes to the length of the staminal tube is important: in *C. argenteiformis,* for instance, the tube is slit down $\frac{1}{2}$ to $\frac{2}{3}$ of its length, whereas in the other related species it is slit down to less than half its length. This character must be studied in flowers just before, during or just after anthesis, because once the seeds start developing the ovary swells and ruptures the staminal tube, so that in older flowers between the lobes deep sinuses or slits are often found which are of a secondary nature.

(d) *Colour of the flowers*

In several keys reference is made to the colour of the flowers, but the colour of the tepals is usually pink to pinkish-mauve in *Pseudohermbstaedtia* and in *Hermbstaedtia,* though somtimes almost white and sometimes darker (carmine or magenta). These colours usually fade in herbarium specimens, the pale colours usually turning scarious white to straw-colour, occasionally brownish or golden-yellow. The tepals of *Hermbstaedtia odorata* can be pink or mauve to deep magenta (occasionally orange-brown?) so that all *Hermbstaedtia* keys based on the colour of the flowers are practically useless, the more so because most authors have only seen dried specimens and these of varying age.

(e) *Number of veins in the tepals*

The number of veins in the tepals varies, even in those of one flower, but it shows a certain average. Unfortunately, this number is usually about three in *Pseudohermbstaedtia* and mostly about five in several species of *Hermbstaedtia,* so that it is not possible to distinguish the species within each genus by the number of veins in the tepals.

(f) *Number of style-branches*

Schinz (in Vrtlj. schr. naturf. Ges. Zürich **56**: 231 (1911)) mentions that in his specimen of the type gathering of *Hermbstaedtia caffra* (viz. *Krauss* 37) the styles are 2-fid or 3-fid, although both Fl. Trop. Afr. and Fl. Cap. mention 2-fid styles exclusively. Meissner's original diagnosis and Moquin-Tandon's description of *H. caffra* reported 3 styles. I have not seen *Kraus* 37, but in several specimens which undoubtedly represent *H. caffra* (such as *Wood* 77 and a *Drège* gathering) both 2-fid and 3-fid styles are present.

H. rubromarginata C. H. Wright was described as having 4-5 style-branches. An isotype (in PRE) was studied by Burtt-Davy who in his key to the species of *Hermbstaedtia* (Man. Flow. Pl. Transv. **1**: 179), mentions: "Stigm. 3-4(5?)" and he evidently never found 5-fid styles. I also failed to find 5-fid styles and I did not find many 4-fid ones either, indeed most of the flowers of the isotype in PRE have 3-fid styles. "Typical" specimens of "*H. elegans Moq.*" have 3(-4)-fid styles and that is why I agree with Burtt-Davy in reducing *H. rubromarginata* to *H. elegans* Moq. (=*odorata*).

For the same reason the recently described *Hermbstaedtia tetrastigma* Suesseng. which was reported to have 4 stigmas (actually there are 3 or 4) has to be sunk under *H. odorata*.

In Fl. Trop. Afr. **6**, 1: 25 "*Hermbstaedtia linearis*" is distinguished in the key from *H. argenteiformis* and *H. falcata* by the 2-fid style (as against 3-fid in the other species). An isotype of *H. linearis* (*Schinz* 1 in GRA) examined by me shows both 2- and 3-fid styles. Specimens which are undoubtedly referable to *H. argenteiformis* Schinz on the other hand often have 2-fid and 3-fid styles, so that this character is useless to separate these forms. Nevertheless, Suessenguth in his paper on the South West African Amaranthaceae uses this character again in the key and perpetuates the error.

Celosia digyna Suesseng. was described from *Dehn* 112 and is supposed to have constantly 2 stigmas. However, the isotype in SRGH has both 2-fid and 3-fid styles and on a determinavit label Suessenguth himself has written "*Celosia digyna* Suesseng. Forma ad *C. trigyna* vergens: styles 2-fid and 3-fid". I found several other specimens with 2-fid and 3-fid styles next to specimens with apparently only 2-fid or only 3-fid styles, so that I am of the opinion that *Celosia digyna* Suesseng. is at the most merely a form of *C. trigyna* L., but not even worthy of a varietal rank.

A similar relationship may exist between *Celosia laxa* Schumach. et Thonn. with mostly 3-fid styles and *C. loandensis* Baker with usually 2-fid styles. The African species of *Celosia* sens. strict. are badly in need of a revision and it is to be hoped that the next monographer will not make the same mistake again of contributing too much significance to the number of style-branches. Sometimes flowers with 4 stigmas occur in *Celosia* sens, strict. (I found them in *Celosia laxa: J. Léonard* 325, Eala, Belgian Congo, in SRGH, and in *C. trigyna: Faulkner* 46 from Portuguese East Africa, in SRGH.)

(g) *Size and shape of the ovary and capsule*

The shape of the ripe capsule is largely dependent on the number of mature seeds (see below) and is of little taxonomic value. The shape of the *young* ovary is also subject to variation and I have not found sufficiently clear differences between the species studied.

(h) *Number of seeds per capsule*

In the key to the species of *Celosia* in Fl. Trop. Afr., Baker and Clarke use the number of mature seeds per capsule to distinguish *C. nana* and *C. populifolia* ("capsules 1-seeded") from the other species with bifid styles ("capsules several-seeded, 1-seeded capsules very rare"). A duplicate (in NH) of *Schweinfurth* 1048, referred to *C. populifolia* by Baker, has 1-4-seeded capsules. Moquin-Tandon also mentions 2-4-seeded capsules. The number of ovules in *Celosia* is often 6 or more (in *C. argenteiformis*, for instance, up to 12 mature seeds are found in one capsule), but usually fewer seeds develop than there were ovules.

The number of mature seeds seems to be too variable a character to be of real value, because it seems to depend on the number of successful fertilizations.

(i) *Structure of the surface of the testa*

Schinz (op. cit., 1933) has pointed out that in some species of *Celosia* sect. *Lestibudesia* the ripe seeds are smooth (or nearly so) and shiny, whereas in other species the seed coat is finely tuberculate or areolate and dull. This is, in my opinion, probably a constant and reliable character and very useful to distinguish at once between species which are otherwise very similar, e.g., between *C. loandensis* Bak.f. or *C. laxa* Schumach. & Thonn. (with tuberculate or areolate seeds) and *C. trigyna* L. (seeds nearly smooth and shiny) or *C. schweinfurthiana* Schinz (seeds smooth).

Celosia trigyna L. has usually sessile stigmas, but occasionally a short, but distinct style is present. Suessenguth (in Mitt. Botan. Staatssamml. München **1**, 3: 75 (1951)) mentions several specimens under a "var. *longistyla*" and states that some could equally well be called "*C. loandensis* Baker var. *longistyla*", but he prefers to retain them in *C. trigyna* on account of the number of style-branches. I have not seen any of the specimens quoted by Suessenguth, but the structure of the testa in these specimens might be conclusive in deciding if they are referable to *C. trigyna* or to *C. loandensis*.

ENUMERATION OF THE SPECIES OF *CELOSIA* AND *HERMBSTAEDTIA* OCCURRING IN SOUTHERN AFRICA

Celosia L., Sp. Pl.: 205 (1753); Moq. in DC., Prodr. **13**, 2: 238 (1849); Lopriore in Engl., Bot. Jahrb. **30**: 102 (1901); Schinz in Engler & Prantl, Natürl. Pflanzenfam. ed. 2, **16**c: 29 (1938); Suessenguth in Mitt. Botan. Staatssamml. München **1**, 5: 140 (1952).

The type species is *Celosia argentea* L., so that the following subdivision has to be made according to the latest Code (modified from Schinz 1933):

Subgenus 1. *Celosia* (= subgenus *Eucelosia* Schinz)

Section 1. *Celosia* (= *Celosiastrum* Moq., maintained by Schinz)

Section 2. *Lestibudesia* (Petit-Thou.) Moq. (inclusive of sect. *Celosiella* Moq.)

Section 3. *Lageniformes* Schinz

Subgenus 2. *Pseudohermbstaedtia* Schinz (incl. subgenus *Gomphrohermbstaedtia* Lopr.)

Type species: *Hermbstaedtia argenteiformis* Schinz = *Celosia argenteiformis* (Schinz) Schinz

For details cf. Lopriore, l.c., and Schinz (1933, l.c.), see also p. 145 and p. 146.

The subgenus *Celosia* is represented in South Africa by one species only, but a second, perhaps undescribed one, occurs in Portuguese East Africa. They can be distinguished as follows:

Plant (almost) completely glabrous; perianth usually drying scarious white, about 3 mm. long, style as a rule very short to O, seeds faintly rugose, appearing smooth, shiny . . . . 1. *C. trigyna*

Branches, main nerves of leaves and petioles hispidulous; perianth when dry usually distinctly brownish, up to about 5 mm. long; style at least ⅓ the length of the young capsule; seeds finely but distinctly rugose when ripe and rather dull . . . . 2. *C. spec.* cf. *C. cuneifolia* Baker

The subgenus *Pseudohermbstaedtia* is practically restricted to Southern Africa with its centre of distribution in South-West Africa, Angola and Bechuanaland. About 15 species have been described, which in my opinion have to be reduced to five only. They can be distinguished as follows:

Low glabrous undershrub, usually less than 30 cm. high, many-stemmed and branched from the base; leaves distinctly obovate-spathulate, rather thick (almost fleshy), up to ca 1.5 cm. long; inflorescences capitate, more or less globose, numerous at the ends of the branches and often also in the forks of the upper ramifications of the stems; peduncles mostly obscure or none and heads more or less sessile among upper leaves (sometimes apparently involucrate by upper leaves); perianth pinkish-white (scarious-white or straw-coloured when dry); staminal tube of P-type, free parts of filaments rather long for this subgenus, subulate; stigmas as long as the style, more or less erect and hardly spreading in specimens studied (not recurved); ovary already about as long as staminal tube in young flowers and comparatively large; seeds in specimens seen apparently brown when mature (not black). Only recorded from the arid coastal zone of S.W. Africa (Namib) and an adjoining strip of country . . . 3. *C. spathulifolia*

Plants annual. Leaves linear or lanceolate-oblong to ovate or orbicular, often over 1.5 cm. long; inflorescences (when well-developed) spicate, often elongated (when young, retarded or depauperated more or less capituliform), usually distinctly pedunculate; perianth pink, mauve or carmine, or longitudinally streaked with pink or red, but in old specimens and when dried often faded to scarious white or straw colour; stigmas usually spreading or recurved, often exserted in older flowers; mature seeds black:

> Apical portion of ovary and of mature capsule covered with flat broad obtuse papillae (visible with a hand-lens or even with the naked eye); vegetative parts pubescent usually ultimately more or less scabrid . . . . 4. *C. scabra*
>
> Apical portion of ovary and of mature capsule glabrous or rarely minutely papillose (papillae not or hardly visible with a hand-lens):
>
> > Perianth usually 8-10 mm. long; spikes (at least the terminal ones of the main stems) usually very dense, continuous, often cylindric with rounded tops, 16-30 mm. in diam.; staminal tube of G-type, slit down between the anther-bearing lobes from $\frac{1}{2}$-$\frac{2}{3}$ of its length; seeds often numerous (up to 12 in. specimens studied); plant almost invariably quite glabrous . . . . . 5. *C. argenteiformis*
> >
> > Perianth usually less than 8 mm. long, if longer, staminal tube of P-type; spikes various, but usually less than 20 mm. in diam.; staminal tube of P-type and/or plant more or less hairy; staminal tube slit down between the anther-bearing lobes to less than half its length:
> >
> > > Leaves usually sessile or subsessile, often more or less lanceolate or linear; spikes always simple; staminal tube of G- or P-type or of both types mixed . . . . 6. *C. linearis*
> > >
> > > Leaves conspicuously petiolate, ovate to almost orbicular, up to about 3 cm. long and as wide, truncate, rounded or subcordate at the base; petioles up to 4 cm. long; spikes usually not simple, but often branched or lobed at the base (resembling those of several species of *Celosia* sect. *Lestibudesia);* staminal tube of P-type . . . . 7. *C. schaeferi*

1. **Celosia trigyna** L., Mant.: 212 (1771); Moq. in DC., Prodr. **13**, 2: 240 (1849); Baker & Clarke in Dyer, Fl. Trop. Afr. **6**, 1: 19 (1909); Cooke & Wright in Dyer, Fl. Cap. **5**, 1: 404 (1912); Burtt-Davy, Man. Flow. Pl. Trans. **1**: 179 (1926); Suesseng. in Mitt. Bot. Staatssamml. München **1**, 5: 140 (1952). Type: from Senegal.

Celosia digyna Suesseng. in Mitt. Bot. Staatssamml. München **1**, 3: 73 (1951), nomen tantum, et in Trans. Rhodesia Sci. Assoc. **43:** 8 (1951), descr., non *Celosia digynia* Sessé & Moq., Pl. Nov. Hispan. ed. 1: 40 (1887-1890), ed. 2: 38 (1894). Type: *Dehn* 112 from S. Rhodesia (M, holo., PRE, SRGH, isos.!).

General distribution: throughout tropical Africa, also in Madagascar and in Arabia.

This well-known species is extremely variable. The inflorescence can be laxly paniculate or consists of dense subglobose clusters of flowers arranged in an interrupted linear panicle. There is also a considerable variation in the length of the style and the filaments, so that I do not think Suessenguth's subdivision of *C. trigyna* into a number of varieties and subvarieties in Mitt. Bot. Staatssamml. München **1**, 3: 75 (1951) is of any practical value.

As I have pointed out already, the isotypes of *Celosia digyna* Suesseng. (*Dehn* 112 in PRE and SRGH) possess flowers with 2 stigmas and flowers with 3 stigmas. It is true that specimens with mostly 2 stigmas are *usually* of a more slender habit than those with 3 stigmas, and often have more or less lanceolate leaves instead of ovate or ovate-hastate leaves as in "typical" *C. trigyna* (with 3 stigmas) and bear smaller flowers, but there are exceptions, such as plants with the habit of the typical form and mostly 2 stigmas (e.g., *Faulkner* K 46, *Whellan* 61 in SRGH, *Van Dam* s.n. in PRE) and plants with mostly 3 stigmas and the slender habit of "*C. digyna*" (e.g., *Chase* 749 in SRGH). Plants with about equal numbers of 2-fid and 3-fid styles are often intermediate in habit between the two extreme forms. Accordingly, not a single character can be found to separate "*C. digyna*" from "*C. trigyna*". Suessenguth annotated several specimens (in SRGH) with 2 stigmas and 3 stigmas on the same plant: "*Celosia digyna* Suesseng., forma ad *C. trigyna* vergens,", but such practice is not to be recommended as it is entirely at variance with current concepts in practical taxonomy.

The two forms cannot be more than "formae" in the taxonomical sense. Apart from these taxonomical considerations the name *C. digyna* Suesseng. cannot be upheld on account of the older homonym *C. digynia* Sessé et Moq. *Celosia trigyna* has been recorded from South West Africa (Okavango area), Bechuanaland Protectorate, Transvaal (Soutpansberg, Pietersburg, Letaba, Nelspruit, Barberton), Swaziland, Natal from Zululand southwards and extending in the coastal zone to the E. Cape as far as Kentani.

2. **C. spec.** cf. *C. cuneifolia* Bak.

The specimens cited below, all from the southern part of Portuguese East Africa, belong to one taxon which is related to *C. cuneifolia* Baker, *C. loandensis* Bak. and *C. pandurata* Bak. They may represent an undescribed species but a complete revision of all described taxa in this group (sect. *Lestibudesia*) is needed before its status can be decided. These specimens differ from *C. cuneifolia* in that they are conspicuously hispidulous on the branches, petioles and principal veins of the leaves, and from *C. loandensis* Baker and *C. laxa* Schum. & Thonn. in pubescence (the other two are glabrous or nearly so) and in the structure of the testa which is rugulose as against smooth in the other two. A description is given here to aid future workers: herbaceous, apparently annual, up to at least 50 cm. tall. *Stems* somewhat woody at the base, terete and sulcate, the oldest parts here and there somewhat hispidulous, younger parts more conspicuously so. *Leaves* ovate to panduriform or very faintly 3-lobed, entire, acute, hispidulous on principal veins (usually only on the mid-rib) below, 1.5-4.5 cm. long and 1-3 cm. broad; petioles 0.3-1.5 cm. long, hispidulous. *Inflorescences* terminal, consisting of narrow interrupted lax linear spiciform 8-14 cm. long panicles bearing few-flowered sessile clusters and some solitary flowers, forming lax panicles 20-30 cm. long and broad aggregates. *Bracts* and *bracteoles* triangular, acute, 1-1.5 mm. long. *Tepals* white in the fresh flowers drying pale brown, acuminate, 2-3 mm. long. *Staminal tube* 1.5-2 mm.; filaments linear, about 0.5 mm. long. *Style* a little shorter than the ovary; stigmas 3 or sometimes 2. *Seeds* dull black, minutely rugulose (not pitted as in C. *loandensis*).

PORTUGUESE EAST AFRICA.—Lourenço Marques distr.: Lourenço Marques, *Bremekamp* LM85, *Borle* 466 (PRE); Bela Vista Plain, *Hornby* 4613 (PRE); Maputoland, leg. N.N. as "*Maputoland Exped. Transv. Mus.*" no. TRV 14307 (PRE, BOL), *Wager* s.n. (GRA), *Gomes e Sousa* 3780 (PRE).

3. **Celosia spathulifolia** *Engl.* in Engl., Bot. Jahrb. **10**: 6 (1888) ("*spathulaefolia*"); Schinz in Engl., Bot. Jahrb. **21**: 180 (1895); Suesseng. in Mitt. Bot. Staatssamml. München **1**, 5: 140 (1952). Type: South West Africa, Walvis Bay, *Marloth* 1205 (PRE, iso.!).

C. intermedia Schinz, tom. cit.: 179, non Hochst. Type: South West Africa, Rehoboth, *Fleck* 177 a (Z, holo.).

Hermbstaedtia spathulaefolia (Engl.) Baker in Dyer, Fl. Trop. Afr. **6**: 29 (1909).

SOUTH WEST AFRICA.—Swakopmund: *Lanjouw* 7, 17 (U); Swakop River, *Cannon* in Herb Marloth 10557 (PRE); Rössing, *Dinter* 2805 (SAM), *Boss* A 70 (PRE). Omaruru: Brandberg, *Liebenberg* 4989 (PRE); Welwitsch, *Galpin & Pearson* 7463 (PRE; SAM). Also collected farther north (Omaruru, Kaokoveld) by *De Winter & Leistner* (PRE).

4. **C. scabra** (Schinz) Schinz in Engl. & Prantl, Natürl. Pflanzenfam. **3**, 1A: 100 (1893); ed. 2, **16**c: 30, f. 11c (1933), et in Engl., Bot. Jahrb. **21**: 180 (1895); Lopriore in Engl., Bot. Jahrb. **30**: 104, f. lc (1901); Suesseng. in Mitt. Bot Staatssamml. München **1**, 5: 141 (1952); Meeuse in R. A. Dyer, Flow. Pl. Afr. **31**, 4 (no. 124): t. 1265 (1957).

Hermbstaedtia scabra Schinz in Verh. Bot. Ver. Brandenb. **31**: 209 (1890); Baker & Clarke in Dyer, Fl. Trop. Afr. **6**, 1: 28 (1909); Burtt-Davy, Man. Fl. Pl. Transv. **1**: 180 (1926), *exclus. spec. transvaal.* Type: South West Africa, Ovamboland, Olukonda, *Schinz* 3 (Z, holo.).

Hermbstaedtia ovata Dinter in Fedde, Repert. **18**: 255 (1922), nomen subnudum. Type: South West Africa, Otjituo, *Dinter* 643 (NBG-SAM, iso-syn.!).

This species is characterized by its distinctly papillose capsules. This character was overlooked (or the species was misunderstood) in Fl. Trop. Afr., because among the specimens quoted under *H. scabra* is *Mrs. Lugard* 196. A duplicate of this number (in GRA) has a glabrous ovary and is, therefore, referable to *C. linearis* sens. lat. Burtt-Davy was apparently also not aware of the importance of this character (which, incidentally, was only emphasized by Schinz in his later publications) and several of the specimens Burtt-Davy quoted under *Hermbstaedtia scabra* (*Galpin & Pearson* 7541, *Moss & Rogers* 59) do not belong here but are referable to *Celosia linearis*. On the other hand Burtt-Davy described a "*Hermbstaedtia rogersii*" (see under 6. *Celosia linearis*) as having papillose ovaries. This is a bit of a mystery because the type of "*H. rogersii*" has a somewhat rugulose ovary but the latter is certainly not distinctly pubescent or papillose and I cannot distinguish *H. rogersii* from *Celosia linearis*.

Dr. L. E. Codd of the National Herbarium visited Barotseland in August, 1952, and collected seeds of *C. scabra*. Plants grown from these seeds at the Division of Botany, Pretoria, were perfectly constant in their characters and showed the typical papillose capsules. Dr. Codd reported that the plant is apparently an annual, because the plants were dying off when the seeds were ripening. This was confirmed by the plants grown in Pretoria. In about three months the plant started flowering and they flowered freely for 2-3 months, reaching a height of 75-90 cm., but subsequently died. The colour of the perianth is a deep rich amaranth-pink and not "scarious white" as reported in Fl. Trop. Afr. **6**, 1: 28. These cultivated specimens were used for the plate and descriptions in Flow. Pl. Afr. **31**, 4 (124): t. 1236.

Hermbstaedtia ovata Dinter was published by Dinter in a list of S.W. African plants and the fact that he gave a few descriptive remarks just saves it from being a nomen nudum. A duplicate of *Dinter* 643, one of the specimens quoted by Dinter, proves to be typical *Celosia scabra*, so that Dinter's name becomes a synonym of the latter.

SOUTH WEST AFRICA.—Okavango: Diyona Camp near Nyangana Mission Station, *De Winter & Wiss* 4464 (PRE). Grootfontein, *Schoenfelder* S. 409 (PRE); Karakuwise, Cigarette, *Maguire* 2313 (NBG, PRE) id. Chassie, *Maguire* 2115 (NBG); Otjimavere, *Dinter* 2371 (SAM). Caprivi Strip: *Kruger* "nr. E." (PRE); Eastern part of Caprivi Strip, *Killick & Leistner* 3156 (PRE; SRGH).

BECHUANALAND PROTECTORATE. *Miller* B/1164 (PRE).

NORTHERN RHODESIA. Barotseland: *Borle* 26 (PRE).

5. **C. argenteiformis** (*Schintz*) *Schintz* in Engl & Prantl, Natürl. Pflanzenfam., **3**, 1A: 100 (1893); ed. 2, **16**c: 30 (1933), in Engl., Bot. Jahrb. **21**: 180 (1895), et in Bull. Herb. Boiss. (1re sér.) **5**, Append. 3: 63 (1897), inclus, var. *oblongifolia* Schinz; Lopr. in Engl., Bot. Jahrb.

30: 5, 104 f. 1D (1901); Suesseng. in Mitt. Bot. Staatssamml. München **1**, 5: 141 (1952).

Hermbstaedtia argenteiformis Schinz in Verhandl. Bot. Ver. Brandenb. **31**: 209 (1890); Baker & Clarke in Dyer, Fl. Trop. Afr. **6**, 1: 26 (1909). Syntypes: Angola, *Welwitsch* 6502 (K, iso.), South West Africa, *Belck* 45a (not seen).

H. welwitschii Baker in Kew Bull **1897**: 278 (1897), non *Celosia welwitschii* Schinz. Type: Angola, *Welwitsch* 6502 (K, holo.).

Celosia toenjesii Schinz in Bull. Herb. Boiss. 2me sér. **3**: 8 (44) (1902). Type: South West Africa, Ovamboland, *Toenjes* 19, 25 (Z, syns.),

Mr. B. de Winter compared some of the specimens cited below with *Welwitsch* 6502 (in K) and reported that they agree with this gathering in habit and in the structure of the staminal tube so that the identity was established.

C. argenteiformis is characterized by the lack of pubescence, the broad inflorescences and the large (8-10 mm. long) tepals. The staminal tube is consistently of the G-type and invariably slit down to $\frac{1}{2}$-$\frac{2}{3}$ of its total length between the anther-bearing lobes. These characters distinguish it from all other species, although luxuriant forms of *C. linearis* are sometimes very similar in habit (if they are glabrous, they can still be distinguished by the structure of the staminal tube).

Some specimens have broader leaves than the type gatherings and also seem to differ in that the spikes are more or less tapering (not rounded) at the apex. These plants, which probably represent the var. *oblongifolia* of Schinz, are sometimes strikingly similar to *Celosia argentea* L. (especially the gathering *De Winter & Leistner* 5612 cited below) and an examination of the staminal column is required to decide the identity of such specimens.

SOUTH WEST AFRICA.—Kaokoveld: Omutati, *Hall* 378 (NBG); sandy flats S. of Ombombo on road to Sesfontein, *De Winter & Leistner* 5612 (PRE); 6 m.E. of Ohopoho on road to Ovamboland, *De Winter & Leistner* 5330 (PRE); Kaientes, Thorne in SAM 28770 (NBG). Karibib: Karibib, *Kinges* 3378 (PRE); Ababis, *Dinter* 219 (NBG); Usakos, *Marloth* 1262 (PRE), Okongawa/Karibib, *Seydel* 758 (PRE). Gibeon: *Range* 1342 (NBG). Keetmanshoop?: "Kubis" (Kuibis?), *Mücke* 64 (PRE). Lüderitzbucht: Lüderitz, *Kinges* 2400 (PRE). District unknown to me: Klein Ameib, *Dinter* 7064 (BOL; PRE); Tsamkubis, *Dinter* 2200 (SAM).

Also in Angola.

6. **C. linearis** *(Schinz) Schinz* in Engl. & Prantl, Natürl. Pflanzenfam. **3**, 1A: 99, 100 f. 51D (1893); ed. 2, **16**c: 30, f. 11E (1933), et in Engl., Bot. Jahrb. **21**: 180 (1895); Lopriore in Engl., Bot. Jahrb. **30**: 5, 104 f. 1E (1901); Suesseng. in Mitt. Bot. Staatssamml. München **1**, 5: 142 (1952).

Hermbstaedtia linearis Schinz in Verhandl. Bot. Ver. Brandenb. **31**: 210 (1890); Clarke in Dyer, Fl. Trop. Afr. **6**, 1: 27 (1909); Burtt-Davy, Man. Flow. Pl. Transv. **1**: 180 (1926). Type: South West Africa, "Amboland, Uppingtonia" *(recte*: Grootfontein), *Schinz* 1 (Z, holo., GRA, iso.!).

Celosia welwitschii Schinz in Engl., Bot. Jahrb. **21**: 179 (1895), non *Hermbstaedtia welwitschii* Bak. in Kew Bull. **1897:** 278 (1897). Type: Angola, Huilla, *Welwitsch* 6486 (K, iso.).

C. falcata Lopriore in Engl., Bot. Jahrb. **27**: 58 (1899) et **30**: 5, 104, f. 1F (1901), e descr. Type: Angola, Huilla, *Capello* 4 (not seen).

C. fleckii Schinz in Bull. Herb. Boiss. 2me sér. **3**. 8, 44 (1903). Type: South West Africa, Rehoboth, *Fleck* 35, 939 (Z, syns.).

C. namaensis Schinz in Vtljschr. naturf. Ges. Zürich **76**: 134 (1931). Type: South West Africa, Rehoboth-Aub, *Dinter* 224 (SAM, iso.!).

C. humilis Suesseng. in Mitt. Bot. Staatssamml. München **1**, 1: 4 (1950). Type: Transvaal, Wylie's Poort, *Lanjouw* 851 (U, holo.!).

C. rogersii (Burtt-Davy) Suesseng., tom. cit., 106 (1952).

C. Schinzii (C. B. Clarke) Suesseng. tom. cit., 142 (1952).

C. longistyla (C. B. Clarke) Suesseng., l.c.

C. exellii Suesseng., tom. cit., 186 (1953), e descr. Type: Angola, Mossâmedes, *Carisso & Mendonça* 301 (BM, holo.).

Hermbstaedtia falcata (Lopr.) C. B. Clarke apud Baker & Clarke, tom. cit.: 27.

H. schinzii C. B. Clarke, l.c. Type: South West Africa Ovamboland, *Rautanen* 73 (K, holo.).

H. longistyla C. B. Clarke, tom. cit., 28. Type: South West Africa, "Dammaraland", *Een* (not seen).

H. fleckii (Schinz) C. B. Clarke, l.c.

H. angolensis C. B. Clarke, op. cit., 29. Type: the same as that of *C. welwitschii* Schinz.

H. rogersii Burtt-Davy, op. cit.: 43 (descr.), 179, 180. Type: Transvaal, Soutpansberg, Messina, *Rogers* 19444 (PRE, holo.!, K, iso.).

I have tried in vain to separate the material referred here to *C. linearis* into correlated groups, using several characters (habit, shape of inflorescence, pubescence, type of staminal column, number of style-branches, even geographical distribution, etc.). The forms all intergrade and I can only refer them all to one rather variable taxon. Apart from the synonyms of which I have seen the types I have referred a few names here *e descr*. because all specimens studied which came from a large area including Angola, Bechuanaland Protectorate, South West

Africa, the Northern Cape Province (Griqualand-West) and the Transvaal, all fit into this concept of a variable single taxon. It has been pointed out (on pp. 147-153) that several alleged differential characters such as the number of style-branches and even the mode of lobing of the staminal tube (both G- and P-type and intermediates occur, sometimes in a single inflorescence or in one flower!) are not constant. Several described forms are juvenile, retarded, depauperated, grazed or luxuriant stages, but in cultivation the specimens appeared constant in habit (though, of course, "luxuriant"). The only form that seemed to differ, was Burtt-Davy's *"Hermbstaedtia rogersii"*, for it was described as having papillose (or "pubescent") ovaries. However, when I examined the types (*Rogers* 19444 in PRE) and paratypes (*Galpin & Pearson* 7541), I had some difficulty in seeing a manifest pubescence or papillosity. The ovary appears rugulose it is true, but I doubt if in fresh specimens the ovary is not smooth (perhaps minutely puberulous). Similar rugulose ovaries are found in other specimens not distinguishable from "good" *C. linearis* and in all other respects. *"H. rogersii"* falls well within the range of *C. linearis* in my circumscription, so that I do not hesitate to reduce it to synonomy. The only species with a clearly papillose ovary is *Celosia scabra,* but *H. rogersii* has certainly nothing to do with it: the papillae on the ovary in *C. scabra* are conspicuous, flattened, broad and obtuse or truncate and in other respects (pubescence and ecology) this species is also quite distinct (and hence easily separable) from the *C. linearis* complex.

Suessenguth, who saw several of the PRE specimens, evidently had the same difficulties in identifying them, because he referred some of them to *C. linearis, C. fleckii, C. cf. welwitschii, "C. rogersii* vergens ad *C. fleckii"* or even *"C. rogersii* vergens ad *C. fleckii* vel ad *C. linearis*". Apart from the fact that some of these interpretations are, to my mind, altogether wrong (*C. scabra*!) the phrase "vergens ad" is nothing but an admission of defeat by the systematist.

SOUTH WEST AFRICA.—Caprivi Strip: Eastern part, *Killick & Leistner* 3100 (PRE). Kaokoveld: Otjinungua, *De Winter & Leistner* 5758 (PRE). Grootfontein: Grootfontein, *Schoenfelder* S 466 (PRE), *De Winter* 2988 (PRE); Namutoni, *Breyer* s.n. (PRE); Cigarette near Karakuwise, *Maguire* 2405 (NBG). Omaruru: Omitara, *Liebenberg* 4574 (PRE); Pamela, *Volk* 2902 (PRE). Okahandja: Eahero, *Dinter* 3417 (NBG); Otjisaza, *Dinter* 4570 (PRE). Karibib: Welwitsch, *Galpin & Pearson* 7451 (BOL; NBG; PRE); Spitzkopje, *Boss* s.n. (PRE). Gobabis: 12.7 miles W. of Gobabis, *De Winter* 2494 (PRE). Gibeon: Elephanten-fluss, *Range* 1460 (NBG). Keetmanshoop: 7 m. W. of Aroab, *De Winter* 3389. District unknown to me: Nuitsas, *Dinter* 2311 (NBG); Narib, *Dinter* 2986 (NBG).

CAPE PROVINCE.—Gordonia: Kalahari Gemsbok Game Reserve, *Brynard* 207 (PRE), *Story* 5573 (PRE); Gordonia, *Pole Evans* 2203 (PRE); Upington, *Glover* h. no. 10433 (BOL), *Stephens* h. no. 18269 (BOL). Kenhardt: *Wasserfall* 1031 (PRE). Prieska: Niekerk's Hoop, *Bryant* 381 (PRE). Hay: Black Ridge, *Wilman* s.n. (BOL h. no. 24969). Barkly-West: Barkly-West, *Esterhuysen* 1122 (BOL); Newlands, *Lewis* h. no. SAM 54151 (NBG). Vryburg: Vryburg, *Henrici* 124 (PRE). Mafeking: *Theiler* s.n. (PRE).

TRANSVAAL.—Potchefstroom: Potchefstroom, *Murray* 768 (PRE). Potgietersrust: Potgietersrust, *Pole Evans* 3910 (PRE); near Grass Valley (E. of Roedtan), *Meeuse* 9607 (PRE). Lydenburg: Sekukuniland, *Barnard & Mogg* 1041 (PRE); Olifants River Valley, *Pole Evans* 4694 (PRE); farm Zoetvelden, *Barnard* 381 (PRE); near Driekop, *Meeuse* 9296 (PRE). Soutpansberg: near Saltpan, *Schweickerdt & Verdoorn* 481 (PRE); Messina, *Pole Evans* 1705 (PRE); Dongola, *Pole Evans* 4468, 4559, *Bruce* 49 (PRE).

BECHUANALAND PROTECTORATE.— Takoon: *Burtt-Davy* 13982 (PRE). Kanye: *O. B. Miller* B/1014 (PRE). Kauke: *Van Son* s.n. (PRE). N'gamiland: Kwebe Hills, *Lugard* 196 (GRA).

Also in Southern Angola.

7. **C. schaeferi** *Schinz* in Vtljschr. naturf. Ges. Zürich **66**: 221 (1921), e descr. Type: South West Africa, Gawachab between Seeheim and Kalkfontein, *Schaefer* s.n.

Hermbstaedtia schaeferi Schinz et Dinter, ex Dinter in Fedde, Repert **18**: 255 (1922), nomen tantum.

This very characteristic species can easily be recognized from the description. The petiolate, roundish leaves, and the interrupted branched or lobed inflorescence distinguish it at once from all other species of the subgenus *Pseudohermbstaedtia*. It resembles species of the subgenus *Celosia* sect. *Lestibudesia* in habit.

SOUTH WEST AFRICA.—District?: Beersheba, on loamy soil S. of the Kanibes River, *Range* 1334 (PRE; SAM).

Hermbstaedtia *Reichb.*, Consp.: 164 (1828); Moq. in DC., Prodr. **13**, 2: 246 (1849); Benth. & Hook f., Gen. Pl. **3**: 25 (1880); Schinz in Engl. & Prantl, Natürl. Pflanzenfam. ed. 2, **16**c: 30 (1933).

Berzelia Mart. in Nova Acta Leop.-Carol. Acad. **13**, 1: 292 (1826), non *Berzelia* Brongn. (1826, Bruniaceae).

Hyparete Rafin., Fl. Tellur. **3**: 43 (1836).

Langia Endl., Gen.: 304 (1837).

Pelianthus E. Mey. ex Moq., l.c. in syn., nomen nudum.

Type species: *Celosia glauca* Wendl. = *H. glauca* (Wendl.) Reichb. ex Steud. (*Berzelia* Mart. was based on *Celosia glauca* and the change to *Hermbstaedtia* does not alter this typification.)

According to Kew Bull. **1935**: 396, *Berzelia* Mart was probably published later than August 1826, whereas *Berzelia* Brongn. was published in August 1826, so that *Berzelia* Brongn. does not need conservation. Accordingly *Berzelia* Mart. has to be replaced by *Hermbstaedtia* Reichb.

Key to the species

Tepals equal, up to 6 mm. long, rarely (in oldest flowers) over 6 mm. long; flowers sessile; style usually very short. Mostly perennials, as a rule over 20 cm. tall:

Inflorescences capituliform, subglobose, occasionally somewhat elongated and spicate:

Inflorescences pedunculate, dense, subglobose, capituliform, never tending to become spicate; tepals drying brownish yellow. A much-branched glaucous-green low shrub or suffrutex, with terete, striate, glabrous branches and few, distant linear or linear-lanceolate subfleshy, glabrous leaves, found in stony places in Namaqualand, Little Bushmanland and the southernmost part of South West Africa . . . . 1. *H. glauca*

Inflorescences not or not so distinctly pedunculate, sometimes becoming somewhat spicate; tepals drying scarious white to pale straw-colour. Plant small, annual, under 20 cm. tall, more or less hairy (at least on rhachis of inflorescence). Transvaal (compare also *H. odorata)* . . . . 2. *H. capitata*

Inflorescence (unless very young) distinctly spicate, usually elongated:

Rhachis of spike (and often other parts of the plant) pubescent; inflorescences usually solitary at the ends of the stems and main branches, simple and uninterrupted, rarely branched or lobed at the base, usually over 1 cm. in diam. Widespread on dry, sandy soil, not in wet coastal areas . . . . 3. *H. odorata*

Rhachis of spike (and other parts of the plant) glabrous; inflorescences terminal, in normally developed specimens branched and consisting of one central spike on a stoutish peduncle and 1-3 or more but usually 2 smaller spikes branching off from near the base of the central spike on a very slender pedicel, very rarely inflorescence simple; spikes slender, less than 1 cm. in diam. Coastal belt of Natal . . . . 4. *H. caffra*

Tepals unequal, the outer one 7-8 mm. long and 3 mm. broad, the other four about 6 mm. long; flowers on about 2 mm. long pedicels, the latter bearing the bracteoles at the apex under the flowers; style long. Annual herb about 20 cm. tall with short, dense, subcapituliform, ovoid or broadly cylindrical inflorescences up to 3.5 cm. long and 2-3 cm. in diam. (Angola) . . . . 5. *H. nigrescens*

1. **H. glauca** *(Wendl.) Reichb. ex Steud.*, Nomencl., ed. 2, **1**: 752 (1840); Moq. in DC., Prodr. **13**, 2: 247 (1849); Cooke & Wright in Dyer, Fl. Cap. **5**, 1: 406 (1910); Schinz in Vtlj. schr. naturf. Ges. Zürich **56**: 230 (1911), et in Engl. & Prantl, Natürl. Pflanzenfam. ed 2, **16**c: 31, fig. 12 (1933); Suesseng. in Mitt. Bot. Staatssamml. München **1**, 5: 142 (1952).

Celosia glauca Wendl., Bot. Beobacht.: 43 (1798), et Hort. Herrenhus.: 4, t.2 (1801). Type? (prob. Iconotype only).

Berzelia glauca (Wendl.) Mart. in Nova Acta Leop.-Carol. Acad. **13**, 1: 292 (1826).

I have not seen the original publication by Wendland, but Mr. B. de Winter kindly consulted it for me at Kew. There seems to be very little doubt that the plants referred to this species by Moquin, Schinz and others represent Wendland's species, because the characteristic capitate inflorescence distinguishes *H. glauca* from all other species and Wendland's excellent plate (showing dissections of the flower) renders the identification quite reliable.

The flowers are pink (sometimes white?) but turn yellowish-brown after drying. The height of the plant is 2-3 ft., according to the various collectors' notes, but Pearson (on *Pearson* 3029) mentions "shrub 8 ft." Mr. Pillans has written on a sheet of *Pearson* 3029 (in BOL): "8 ft. is very tall for this species. Is there some mistake?" I am of the opinion that Mr. Pillans was quite right and that 8 ft. was a mistake. It should have read "3 ft.".

CAPE PROVINCE.—Namaqualand and Bushmanland: Spektakel, *Bolus* 685, Herb. Bolusianum no. 9441 (BOL; GRA; NBG; NH; PRE), *Maguire* 388 (NBG); Buffels River, *R. Schlechter* 11270 (GRA; L; NH; PRE); *Leighton* 1203 (BOL; PRE); *Compton* 17240 (NBG); Mesklip, *Esterhuysen* 5951 (BOL), *Compton* 11306 (NBG); Springbok, *Adamson* 1541 (PRE); *Lewis* h. no. 59154 (NBG), id. Koa Valley, Acocks 14245 (PRE); between Springbok and Soebatsfontein, *Compton* 5459 (NBG); Doornpoort, *Compton* 20627 (NBG); Rietfontein, *Thorns* s.n. (NBG); Richtersveld, Twee-rivieren, *Marloth* 12260 (PRE: heads very small, probably a depauperated specimen or collected in a very dry season); id. Kaboos Mts., *Van Son* s.n. (PRE); Anisfontein, *Pillans* 5313 (BOL); Arrisdrift, *Pillans* 5068 (BOL); Eenriet, *Pearson* 3095 (BOL); between Springbok and Pella, *Thorne* s.n. (SAM); Pella, *Pole Evans* 2346 (PRE). Bushmanland: Naroep, *M. Schlechter* 55 (BOL; L; PRE); Ougrabies, Pearson 3576 (BOL); between Wortel and Dabainoris, *Pearson* 3029 (BOL; GRA; KMG; NBG; PRE); Kweekfontein, *Pearson* 3819 (GRA; NBG); between Steinkopf and Orange River, nr. Henkries, *Phillips* 1622 (NBG); near Verleptpram, *Drège* (L; NBG).

SOUTH WEST AFRICA.—Lüderitzbucht: Kumguib Mts; *Range* 1063 (NBG). Warmbad: *Marloth* 4797 (PRE), *Galpin* 14123 (BOL; PRE); Garies(?), *Dinter* 4245 (NBG); Aiais, Gr. Fish River, *Pillans* 6578 (BOL); Kalkfontein, *Schaefer* 1271 (NBG); Kl. Karas, *Dinter* 3214 (NBG), 4887 (PRE), *Oertendahl* 107 (PRE).

2. **H. capitata** *Schinz* in Vtljschr. naturf. Ges. Zürich **56**: 233-234 (1911); Burtt-Davy, Man. Flow. Pl. Transv. **1**: 179 (1926). *Type: Schlechter* 4239 (Z, holo., BOL, GRA, NH, PRE, isos.!), from Transvaal, distr. Warmbaths, Sandfontein.

After the original type gathering by Schlechter in 1894, this plant was collected only once again by Leendertz in the same area (near Warmbaths) in 1909.

H. capitata is apparently an annual, much branched from the base. Although it has a different habit and a different inflorescence, the floral characters are very similar to those of H. *odorata,* which is fairly common in the same area. It is possible that *H. capitata* is only an annual stage of *H. odorata,* because the area near *Warmbaths* has often been botanically explored (and I searched the area in vain for any other species myself), but only *H. odorata* has been collected since 1909. However, as I have never seen any juvenile forms of *H. odorata* with subglobose inflorescences, I feel that some caution must be exercised and for the present *H. capitata* is maintained here.

TRANSVAAL.—Warmbaths: Warmbaths, *Leendertz* 2017 (BOL, PRE).

3. **H. caffra** *(Meisn.) Moq.* in DC., Prodr. **13**, 2: 246 (1849); Cooke & Wright in Dyer, Fl. Cap. **5**, 1: 406 (1910); Schinz, tom. cit.: 231 (1911).

Lestibudesia? caffra Meisn. in Hook., Lond. Journ. Bot. **2**: 549 (1843), (sphalm. "449"). Type: Natal, *Krauss* 37 (BM, holo., Z, iso.).

Langia celosioides Fenzl ex Drège, Zw. Pfl. geogr. Doc. in Flora, Bes. Beig.: 160, 197 (1843), nomen tantum.

Pelianthus celosioides E. Mey. ex Moq. l.c. in syn., nomen nudum.

I did not see the actual type gathering; the identity is based on descriptions and on specimens referred to this species by several authors (*Drège, Wood* 77).

This plant has been confused with *H. odorata* (=*H. elegans*) e.g., by Lopriore, and even united with some forms (such as "*H. recurva*" by C. B. Clarke, see Fl. Trop. Afr. **6**, 1: 25), but it is quite distinct. Its distinguishing characters were already pointed out by Moquin-Tandon, such as the usually branched inflorescences (often three spikes together, the middle one larger than the two lateral ones: ". . . spicis ternis . . ." and "spicae inaequales, terminalis intermedia semipedalis, lateralis 1-1½ poll. longa . . ."), the habit ("Rami . . . infra medium satis dense foliosi, superne folia pauca longe distantia gerentes") and the lack of any pubescence ("Glaberrima"). These characters clearly distinguish *H. caffra* from all other species of *Hermbstaedtia* including the rather similar *H. odorata.* The number of stigmas is usually 3, as indicated by Meisner and Moquin-Tandon, sometimes 2, but not always 2 as erroneously indicated by Cooke and Wright and by C. B. Clarke. However, Suessenguth still perpetuates this error in his 1952 paper on the South African Amaranthaceae. He also perpetuates another error which has probably originated with Lopriore's publication in Engl., Bot. Jahrb. **30**: 106 (1901). Lopriore referred several specimens from Bechuanaland and South Africa to "*H caffra*" one of which (*Fisher* 27) was referred to "*H. recurva*" by C. B. Clarke (in Fl. Trop. Afr. 6, 1: 26) with the synonym "*H. caffra* Moq. partly not *Lestibudesia? caffra* Meisn." However, *H. caffra* has only been recorded from a narrow coastal strip in Natal from Umzinto northwards into Zululand. All references to *H. caffra* as occurring in the "Kalahari Region" or in South West Africa are erroneous and all specimens from these areas cited as "*H. caffra*" belong to the variable *H. odorata* (= *H. elegans*).

H. caffra is a stout perennial up to about 80 cm. high, leafy below the middle of the stems and with only a few distant small leaves above the middle (*H. odorata* is more or less uniformly leafy throughout). The leaves are large for the genus. The lower ones are distinctly petioled (petioles 10-15 mm. long), the blades are up to 55 mm. long and 10 mm. broad, rather thick (almost leathery), lanceolate-oblong to spathulate-oblong (those of *H. odorata* are usually considerably smaller, narrower and herbaceous).

The inflorescence is very characteristic. Solitary terminal spikes are rare (I saw it only in *Crookes* 2), but the *glabrous* rhachis still distinguishes *H. caffra* from related species.

The spikes are slender in comparison with the size of the whole plant (1 cm. or even less in diam., usually well over 1 cm. wide in *H. odorata*) and the flowers are also smaller (3-4 mm. long) than those of most specimens belonging to the related taxa (4-6 mm. long or over).

NATAL.—Ubombo: *Comins* 10 (NH). Hlabisa: Richards Bay, *Rump* s.n., *Halse* 19, *Lawn* 1687 (all NH). Empangeni: *Stayner* 7 (BOL). Eshowe: Umhlatuzi Swamp, *Kotze* 55 (PRE); Ginginhlovu: *Gerstner* s.n. (NH). Inanda: *Wood* 77 (BOL; PRE). Durban: *Drège* s.n. (L), *Wood* 120 (BOL, NBG). Umzinto: Park Rhynie, *Crookes* 2 (NH). Southern Coast: Shelly Bay, *Mogg* 12078 (PRE).

N.B. A specimen from "Port Natal" (Durban) attributed to Zeyher in NBG-SAM cannot have been collected by Zeyher because he never visited the Durban area. The specimen in question must be very old, because it bears a label in Pappe's handwriting. However, it is impossible to establish its identity; it may be a duplicate of *Krauss* 37.

4. **H. odorata** *(Burch.) T. Cooke* in Dyer, Fl. Cap. **5**, 1:407 (1910); Schinz in Vtljschr, naturf. Ges Zürich **56**: 231 (1911).

Celosia odorata Burch., Trav. S. Afr. **1**: 389 (1822). Type: Cape Province, Griqualand-West between Spuigslagfontein and Vaal River, *Burchell* 1712 (K, holo., PRE, fragment of holo.!).

C. recurva Burch., Trav. S. Afr. **2**: 226 (1824). Type: Cape Province, Griqualand-West, near Griquatown (Klaarwater), *Burchell* 2111 (K, holo.).

Hermbstaedtia elegans Moq. in DC., Prodr. **13**, 2: 247 (1844); C. B. Clarke in Dyer, Fl. Trop. Afr. **6**, 1: 26 (1909); Cooke & Wright in Dyer, Fl. Cap. **5**, 1: 407 (1910); Schinz, tom. cit.: 231; Burtt-Davy, Man. Flow. Pl. Transv. **1**: 179, 180 (1926); Suesseng. in Mitt. Bot. Staatssamml. München **1**, 5: 143 (1952), 191, 192 (1953), inclus. vars. Type: South Africa, "Vaal River" (Orange Free State or S.W. Transvaal), *Burke* 334 (K, holo., NBG-SAM, PRE, isos.!).

H. elegans var. *recurva* (Burch.) Moq., l.c.

H. recurva (Burch.) C. B. Clarke, tom. cit.: 25, exclus. synonyms and specimen quoted; Suesseng., tom. cit.: 143.

H. transvaalensis Lopr. in Engl., Bot. Jahrb. **30**: 105 (1901) et in Malpighia **14**: 429 (1901); Cooke & Wright, tom. cit.; 408; Schinz, tom. cit.: 232; Burtt-Davy, op. cit.: 179; Suesseng., l.c. Type: Transvaal, distr. Lydenburg, Lydenburg, *Wilms* 1254 (AMD, iso.!).

H. laxiflora Lopr., l.c.; Cooke & Wright, tom. cit.: 406; Schinz, l.c.; Burtt-Davy, op. cit.: 179, 180. Type: Portuguese East Africa, Lourenço Marques distr., Ressano Garcia, *Schlechter* 11876 (L, iso.!).

H. dammarensis C. B. Clarke, tom. cit.: 26; Schinz, l.c.; Suesseng., l.c. Type: South West Africa, "Dammaraland", *Een* s.n. (BM, holo.).

H. rubromarginata C. H. Wright in Dyer, Fl. Cap. **5**, 1: 408 (1910) et in Kew Bull. **1910**: 228 (1910); Schinz, tom. cit.; 232. Type: Transvaal, Potgietersrust distr., Moorddrift, *Leendertz* 1326 (K, holo., PRE, iso.!).

H. quintasii Gandog. in Bull. Soc. Bot. France **66**: 222 (1919), *in clavis*. Type: Portuguese East Africa, Lourenço Marques, *Quintas* 65 (holo. prob. in LY).

H. transvaalensis Gandog., l.c., non Lopr., nomen illeg. Type: Transvaal, Tweefontein, *Schlechter* 4253 (BOL, GRA, PRE, isos.!).

H. tetrastigma Suesseng., tom. cit.: 62 (1950). Type: Southern Rhodesia, Birchenough Bridge, *Hopkins* 7029 (M, holo., PRE, SRGH, isos.!).

General distribution: South West Africa, Bechuanaland Protectorate, Cape Province (Griqualand-West), North-Western Orange Free State, Transvaal, Swaziland, Northern Natal, Portuguese East Africa, extending into Angola!, Southern Rhodesia! and possibly East Tropical Africa (*H. gregoryi* C. B. Clarke, tom. cit.: 26 from East Africa is very close if not identical).

A variable plant, which explains the large number of synonyms. Several keys to the species of *Hermbstaedtia* have been made, but most of the characters used break down and several of the "species" are indeed referable to *H. odorata*. Burtt-Davy already pointed out that the number of style-branches in "*H. elegans*" can be 3 or 4 and he quite correctly reduced *H. rubromargina* (supposed to have 5 style-branches, but neither Burtt-Davy nor the present author ever saw more than 4 in the type gathering) to "*H. elegans*". Nevertheless, and also in spite of the fact that Schinz in his later publications had already repeatedly pointed out that in this whole group of species the number of stigmas is not constant, Suessenguth described "*H. tetrastigma*" as a new species from Southern Rhodesia. The isotypes (*Hopkins* 1029 in PRE and SRGH) I examined have 3 or 4 styles (mostly 3!) in the flowers and I cannot separate them from *H. odorata* on other grounds.

Other characters used in other keys include the colour of the flowers (tepals), the length of the style, the leaf shape ("recurved" or "straight", etc.) and the absence or presence of a petiole. These characters are also variable, whilst the colour changes after drying and is sometimes reported as "scarious-white" or "straw-coloured" or even "blackish" depending on the state of bleaching, fading and weathering. The colour of the fresh flowers is indeed variable in this species. The tepals are usually a clear, light, somewhat mauvy pink and this form occurs in the whole or nearly the whole area of distribution. Such specimens turn white or silvery-white in old inflorescences or when they have faded in the herbarium (which sometimes takes years). In the Transvaal and in Griqualand-West the colour is sometimes a darker pink to deep magenta and occasionally in dried material a dull orange-yellow to brown. I have never seen any orange-yellow fresh specimens in the field myself and I am not at all sure whether the yellow to brown colour is not the faded condition of the magenta-flowered form, a similar brownish discoloration being normal in the pink-flowered *H. glauca*. That is why I am inclined to consider Suessenguth's "varieties" *aurantiaca* and *albi-rosea* (tom. cit.: 192) based on the colour of the tepals of *herbarium* specimens of dubious value. There are also specimens with greenish-white or pale greenish-yellow tepals, but I have only seen this colour in dried (though comparatively fresh) specimens and I am not certain whether it is due to fading or represents the living condition. The pink-flowered forms have the tepals occasionally suffused with green (mainly towards the base) and the pink is often rather pale, so that fading of the pink could easily result in a greenish-white to greenish-yellow colour in dried herbarium specimens.

Both the pink and the deep magenta colour forms (and presumably the orange-yellow form if it exists at all) are attractive plants with a rather extended flowering season and certainly worth a trial as ornamentals.

The presence of a distinct (but always short) style in *H. laxiflora* Lopr. was supposed to be the essential difference separating it from "*H. elegans*" (supposed to have "sessile stigmas"). I find all sorts of transitions between "sessile stigmas" and a "distinct style" and do not regard the absence of a (short) style of any taxonomic value.

The only reliable and constant character is the *pubescent rhachis*, which, in combination with such features as the spicate, more or less elongated, continuous and almost invariably solitary (unbranched) spikes, the size of the flowers and the habit renders the identification clear and simple.

The type gathering (*Burchell* 1712) was from a rather depauperated or perhaps from a young plant, but otherwise not distinguishable from the more robust type of *H. odorata* (*Burke* 334) and indeed C. B. Clarke (in Fl. Trop. Afr. **6**, 1: 26) reduced *Celosia odorata* Burch. to a synonym of *Hermbstaedtia elegans* Moq. ("Kew Rule"!). He erred, however, when he reduced *Hermbstaedtia caffra* Moq. to *H. recurva* (his reasoning is completely obscure, because Moquin's *H. caffra* is a well-typified distinct taxon and Moquin placed *Celosia recurva* Burch. as a variety under his *H. elegans* to which it certainly is closely related). Cooke and Wright (in Fl. Cap. **5**, 1: 407) correctly placed *C. recurva* under *H. elegans,* but treated the latter as distinct from *H. odorata*. Schinz (1911) discussed these problems and wondered why Clarke and Wright came to such totally different results although they had studied the same specimens (*Burchell* 1712, 2111, *Burke* 334 and also the gathering *Krauss* 37 of *H. caffra*). However, Schinz (1.c) did not draw the obvious conclusions and, instead of drastically reducing the number of species, maintained nearly all previously described taxa (nine, which I propose to reduce to four).

About 350 specimens of *H. odorata* were studied, representing nearly 250 different gatherings, which are not cited here. *H. odorata* is widespread and, though not exactly common, often locally frequent, but as far as can be ascertained it is restricted to deep, sandy soils in areas with a fairly low rainfall and but little or no winter frosts apparently on slightly acid or neutral to somewhat alkaline soils. The specific epithet "*odorata*" given by Burchell is inappropriate as I have found the flowers to be odourless and not one of the many collectors who made extensive field notes (mentioning, for instance, the attractive colour of the flowers, among other things) reported a conspicuous fragrance.

5. **H. nigrescens** *Suesseng.* in Mitt. Bot. Staatssamml. München **1**: 62 (1950). Type: Angola, Lunda, *Gossweiler* 13936 (K, holo.; fragment in PRE!).

This characteristic species is known only from the type gathering. Its annual habit, the large flowers (for the genus) which are distinctly pedicelled and the unequal tepals distinguish it at once.

LIST OF NAMES AND SYNONYMS

Berzelia Mart. non Brogn. = **Hermbstaedtia** Reichb.

Celosia acroprosodes Hochst.

Celosia argentea L.

Celosia argenteiformis (Schinz) Schinz.

Celosia digyna Suesseng. = C. trigyna L.
Celosia digynia Sessé et Moq.
Celosia exellii Suesseng. = C. linearis e descr.
Celosia falcata Lopr. = C. linearis.
Celosia fleckii Schinz = C. linearis.
Celosia glauca Wendl. = Hermbstaedtia glauca.
Celosia humilis Suesseng. = C. linearis.
Celosia intermedia Schinz = C. spathulifolia.
Celosia laxa Schum. et Thonn.
Celosia linearis Schinz.
Celosia loandensis Bak.
Celosia longistyla (C. B. Clarke) Suesseng. = C. linearis.
Celosia nana Bak. f.
Celosia namaensis Schinz = C. linearis.
Celosia odorata Burch. = Hermbstaedtia odorata.
Celosia populifolia Moq.
Celosia recurva Burch. = Hermbstaedtia odorata.
Celosia rogersii (Burtt-Davy) Suesseng. = C. linearis.
Celosia schaeferi Schinz.
Celosia Schinzii (C. B. Clarke) Suesseng. = C. linearis.
Celosia schweinfurthiana Schinz.
Celosia spathulifolia Engl.
Celosia toenjesii Schinz = C. argenteiformis.
Celosia trigyna L.
Celosia welwitschii Schinz = C. linearis.
Celosiastrum Moq. (sect of *Celosia*).
Celosiella Moq. (sect of *Celosia*)=Lestibudesia Moq., pro parte.
Eucelosia Schinz (subgenus of *Celosia*).
Gomphrohermbstaedtia Lopr. (subgenus of *Celosia*)=Pseudohermbstaedtia Schinz, pro parte.
Hermbstaedtia angolensis C. B. Clarke = Celosia linearis.
Hermbstaedtia argenteiformis Schinz = Celosia argenteiformis.
Hermbstaedtia caffra (Meisn.) Moq.
Hermbstaedtia capitata Schinz.
Hermbstaedtia dammarensis C. B. Clarke = H. odorata.
Hermbstaedtia elegans Moq. = H. odorata.
Hermbstaedtia elegans Moq. var. *recurva* (Burch.) Moq. = H. odorata.
Hermbstaedtia falcata (Lopr.) C. B. Clarke = Celosia linearis.
Hermbstaedtia fleckii (Schinz) C. B. Clarke = Celosia linearis.

Hermbstaedtia gregoryi C. B. Clarke = H. odorata ex descr., vel affinis.

Hermbstaedtia laxiflora Lopr. = H. odorata.

Hermbstaedtia linearis Schinz = Celosia linearis.

Hermbstaedtia longistyla C. B. Clarke = Celosia linearis.

Hermbstaedtia nigrescens Suesseng.

Hermbstaedtia odorata (Burch.) H. Cooke.

Hermbstaedtia ovata Dinter = Celosia scabra.

Hermbstaedtia quintasii Gandog. = H. odorata.

Hermbstaedtia recurva (Burch.) C. B. Clarke = H. odorata.

Hermbstaedtia rubromarginata C. H. Wright = H. odorata.

Hermbstaedtia rogersii Burtt-Davy = Celosia linearis.

Hermbstaedtia scabra Schinz = Celosia scabra.

Hermbstaedtia schaeferi Schinz et Dinter ex Dinter, nom. nud. = Celosia schaeferi.

Hermbstaedtia schinzii C. B. Clarke = Celosia linearis.

Hermbstaedtia spathulifolia (Engl.) Baker = Celosia spathulifolia.

Hermbstaedtia tetrastigma Suesseng. = H. odorata.

Hermbstaedtia transvaalensis Gandog. = H. odorata.

Hermbstaedtia transvaalensis Lopr. = H. odorata.

Hermbstaedtia welwitschii Baker = Celosia argenteiformis.

Hermbstaedtia welwitschii Schinz = C. linearis.

Hyparete Rafin. = Hermbstaedtia Reichb.

Langia Endl. = Hermbstaedtia Reichb.

Langia celosioides Fenzl. ex Drège = Hermbstaedtia caffra.

Langia glauca (Wendl.) Endl. = Hermbstaedtia glauca.

Pelianthus E. Mey. ex Moq. = Hermbstaedtia Reichb.

Pelianthus celosioides E. Mey. ex Moq. = Hermbstaedtia caffra.

Pseudohermbstaedtia Schinz (subgenus of *Celosia*).

NOTES ON *SCLERIA: 1*

THE AFRICAN SPECIES OF *SECT. TESSELLATAE*

by

E. A. Robinson

The annual species of the Section *Scleria* (Berg) Endl. of the genus *Scleria* form a fairly homogeneous group to which the name of the "*Tessellatae*" was given by C. B. Clarke in F.T.A. VIII: 494 (1902). The name is a convenient though not wholly appropriate one. The word "*tessellata*" was of course originally chosen by Willdenow to describe the surface of the achene of one species. Even in that case it was doubtfully accurate. The Roman "tessellae" were invariably square and were generally arranged in straight lines running at right angles to each other. It is true that the lacunae on the surface of *S. tessellata* Willd. and some other species of this group do give a superficial impression of a similar shape and arrangement, but in fact they are rarely square, often not even rectangular, and never disposed in straight lines both vertically and horizontally. Furthermore a number of species generally allowed to fall into this group have achenes that are in no sense whatever "tessellate"; some have them entirely smooth. And at least one species which does not belong to this group has an achene which is as "tessellate" as the best of them, so that incomplete material of it is often attributed to some species of the *Tessellatae*. (This is *S. nyasensis* C.B.Cl. See below under *S. parvula* Steud.)

In his account of the genus in F.T.A. Clarke included in the *Tessellatae* ten species, all of which he seems to have thought were annuals. Two of these, *S. nyasensis* C.B.Cl. and *S. canaliculato-triquetra* Boeck., subsequent collections have shown to be perennials. Of another, *S. complanata* Boeck., the original material is lost and the original description is not precise enough for the name to be given to any existing specimens. The only subsequent systematic account of the African species of the group has been that of Nelmes, who revised the genus (as occurring in Africa) in the Kew Bulletins of 1955 (3) and 1961 (1). This revision included Clarke's remaining seven species together with two more, one *(S. parvula)* hitherto thought to be confined to Asia, and one *(S. mikawana)* unsuspected, though not uncollected, in Clarke's day.

To Nelmes' nine species three more are added in this present account. Two of these are new; the third, revived from synonymy, is of somewhat doubtful status. Furthermore, the possibility of hybrids occurring within the group is tentatively considered. Nelmes' work was so thorough and his descriptions so detailed that about some species it is not necessary to say very much. However, he seems to me to have under-estimated the importance of certain characters, and much interesting material has been collected since his account of the genus appeared.

Some species, therefore, I here deal with in more detail than others. Elsewhere the essentially supplementary nature of my treatment will be apparent.

Except for the Type of *S. tessellata,* of which I have only seen the photographs at Kew, I have examined all the numbers which I quote. The greater part of these are in the Herbaria of the Royal Botanic Gardens, Kew and the British Museum, the authorities of both of which I should like to thank for the opportunities afforded to me; the former especially for their co-operation in enabling me to examine material obtained on loan from Brussels, Paris and Uppsala.

Apart from the Herbarium specimens cited I am fortunate in having been able to study populations of most of the species here dealt with in the field. The exceptions are *S. tessellata, S. hildebrandtii* and *S. parvula;* of these the last two are only known in the African continent from one collection each. While I have, I hope, avoided giving undue weight to characters not apparent in the dried state, I have found these field studies very valuable in enabling me to establish, or at least to estimate, the range of variation, and hence the reliability, of certain diagnostic characters.

Of such characters, the following are those that I have found of most value:

(a) The number of lateral panicles arising from each node. In all the African species of the group this is a good character, i.e. it is not only almost invariably constant within the species but it is associated with other such constant characters. However, three considerations suggest caution here. It is not a constant character in some other species of the genus outside this group; in *S. melanomphala* Kunth, for example, it is variable. Apparent exceptions may occur in depauperate specimens, where sometimes the lowest node may produce one and the upper nodes two or more panicles. And in immature specimens of some species which have two or more panicles to the node there may only appear to be one, the others being undeveloped and concealed within the sheath. (A notable example of this occurs in the Type number of *S. parvula* Steud., q.v.). Nevertheless, in studies of large populations of a number of African species I have found this a reliable and constant character.

(b) The nature of the lateral peduncles. These vary within the group from erect and barely exserted to long and pendulous. Within the species there is very little variation. Upon this character depends the whole shape and appearance of the inflorescence, and in the field, more perhaps than in the Herbarium, it is an easily marked feature.

(c) The achene, more particularly the shape, size and surface relief. The presence or absence of hairs is also important, though not always decisive.

(d) The disk of the achene. This is not as constant in some species as one would like, but it is always of interest.

(e) The relative length of the male spikelets and their pedicels. This is a character which has been largely ignored in the past. In some species it is important. It must, however, be treated with reserve. The length of the pedicel tends to increase with the general development of the inflorescence, so that the male spikelets may appear almost sessile in immature specimens of a plant which at maturity has pedicels as long or longer than the spikelet. Again it is possible that pedicel-length may vary in relation to the general elongation, e.g. in shady habitats, of the inflorescence. Nevertheless this is always a character worth looking at.

It remains, however, that these plants cannot be dealt with satisfactorily until more systematic collection has been done. The immediate purpose of the notes and descriptions which follow is to reveal this need. Existing Herbarium material is in many cases tantalizingly inadequate. This might be said of a good many species of African plants, but it is peculiarly true of the Tessellatae. This is partly because the plants are themselves not conspicuous and are often concealed by the more robust grasses, etc., among which they grow. But it is chiefly because most of the species are superficially so very similar to each other, occur in similar habitats and all apparently at the same season (in Rhodesia at the end of a five to six months' rainy season), and may frequently each be found closely associated with one or more other species of the same group. I have myself in one Northern Rhodesian locality found five different species growing within 50 yards of each other. It may often happen therefore that from any one locality only one species may be collected, others being overlooked as being identical. Another tiresome possibility is that collections of a single number may contain mixed material of more than one species (e.g. Robinson 1674.). Where, as in the case of two of Schweinfurth's numbers, the mixed material has been distributed, taken as Type specimens for different species, and subsequently lost, there is not much one can do about it.

The natural habitat of all the African *Tessellatae* that I have seen is damp or waterlogged ground which remains wet for between five and eight months in the year. In areas where the annual rainfall exceeds 35 in. and where in consequence the bogs and dambos are generally wet throughout the year the *Tessellatae* are usually confined to the edges of the damp areas. In the permanently wet ground their place is commonly taken by the perennials *S. nyasensis* C.B.Cl., *S. melanomphala* Kunth or *S. canaliculato-triquetra* Boeck. Where however the dambos have been disturbed or attempts have been made to drain them the *Tessellatae* may often be found along the edges of channels and ditches.

KEY TO THE AFRICAN SPECIES OF *SCLERIA SECT. TESSELLATAE*

1. Lateral panicles all single at the nodes:

2. Achenes entirely smooth ... ... 1. *S. schimperiana*

2. Achenes not entirely smooth:

3. Lateral peduncles borne on erect peduncles:

4. Achenes not more than 2mm. long including the disk, glabrous or hairy; plants small with stems 3-25 cm. tall 8. *S. patula*

4. Achenes at least 2.5 mm. long including the disk, always glabrous; stems at least 15 cm., usually at least 30 cm. tall:

5. Male spikelets shorter than their pedicles; achenes not shiny ... 7. *S. mikawana*

5. Male spikelets as long as or longer than their pedicels; achenes shiny:

6. Achenes ovoid, irregularly verrucose-lacunose, smoother towards the apex which is always quite smooth ... 2. *S. foliosa*

6. Achenes ellipsoid-cylindric, lacunose, the lacunae being arranged in straight longitudinal rows: surface-relief of achene uniform from base to apex ... ... 3. *S. tessellata*

3. Lateral panicles borne on pendulous peduncles:

7. Achenes globose, always hairy 4. *S. globonux*

7. Achenes ovate to subglobose, hairy or glabrous:

8. Achenes always glabrous; male spikelets shorter than their pedicels; disk without clear lobes ... ... 6. *S. chlorocalyx*

8. Achenes hairy or glabrous; male spikelets as long or longer than their pedicels; disk clearly 3-lobed ... ... 5. *S. bambariensis*

1. Lateral panicles two or more to at least one of the nodes:

9. Lateral peduncles erect; achenes lightly alveolate … … … … … 9. *S. hildebrandtii*

9. Lateral peduncles pendulous:

10. Achenes entirely smooth … … 10. *S. gracillima*

10. Achenes not smooth:

11. Achenes oblong-ellipsoid, glabrous, moderately deeply lacunose; disk not or only faintly 3-lobed … 11. *S. clathrata*

11. Achenes ovate to subglobose, hairy or glabrous, deeply lacunose; disk clearly 3-lobed … … … 12. *S. parvula*

1. **Scleria schimperiana** Boeck. in Linnaea, **38**: 466 (1874).
S. hypoxis Schweinf. ex Boeck., l.c.

An unmistakable species, remarkably constant in character, easily distinguished by the following features:

(a) The achene is globose or flattened-globose and perfectly smooth and glabrous. When fresh it is often a beautiful pale duck-egg blue or emerald green, colours which have always disappeared by the time the plant reaches the herbarium.

(b) The lateral panicles are always single at the nodes; their peduncles are slender and pendulous.

This species is frequently to be found growing with *S. foliosa*, and even appears mixed with it on some herbarium sheets (e.g. those of the Type specimens of *S. dillonii* Boeck., *Quartin-Dillon & Petit* s.n., Oct.-Nov. 1840). At times the two species will grow together in a single clump, so that it is quite difficult to separate the intertwined stems and roots of the two plants. Of the two, *S. schimperiana* comes to maturity about a fortnight earlier.

ETHIOPIA: Chireh Plain, *Quarton-Dillon & Petit* s.n., Oct.-Nov. 1840, p.p.; Senka Berr, R. Reb, *Schimper* 1235; Gallabat, *Schweinfurth* 2054; Woliso, *Mooney* 5852a; Daraba, *Mooney* 6091.

UGANDA: Paloga, E. Acholi, *Purseglove* 1362.

BELGIAN CONGO: Lake Albert, *Van der Ben* 924.

NORTHERN RHODESIA: Solwezi, *Robinson* 3484; Ndola, *Robinson* 3458; Ndubeni, Luanshya Distr., *Vesey-FitzGerald* 2571; Lusaka, *Robinson* 1461; Choma Distr., *Robinson* 2167, 2831, 2848.

SOUTHERN RHODESIA: Salisbury, *Brain* 4133, 4163; Nyamandhlovu, *Plowes* 1587; Gatooma, *Eyles* 5761; Victoria Falls, *Robinson* 1415.

Not known outside Africa.

2. **Scleria foliosa** Hochst. ex A. Rich., Tent. Fl. Abyss. **2**: 509 (1851).
S. dillonii Boeck. in Flora **61**: 38 (1878).
S. dumicola Ridl. in Trans. Linn. Soc., Ser 2, Bot. **2**: 169 (1884).
S. perrieri Cherm., Bull. Soc. Bot. Fr. **70**: 297 (1923).
(? *S. complanata* Boeck. in Flora **67**: 572 (1879).

A plant of variable stature, but when fully developed the largest of the African Tessellatae, reaching in very wet localities a height of very nearly 2 m. Depauperate specimens may be as small as 15 cm. tall, and are not always easy to distinguish from *S. bambariensis*. However, the following characters should be noted:

(a) The achene is ovoid, glabrous, lightly to moderately verrucose-lacunose, the lacunae not forming a clearly-cut pattern on the surface and disappearing altogether towards the apex, which is always quite smooth. The achene is never beaked in the strict sense; the apex is sometimes rounded, sometimes bluntly pointed, and sometimes it ends in a nipple-like swelling.

(b) The lateral panicles are always single at the nodes, and are borne on stout peduncles which are generally stiffly erect, though after maturity they may occasionally be found nodding.

(c) The mouth of the leaf- and bract-sheaths is extended into a tongue with a dark brown margin. This is conspicuous in well-developed specimens.

(d) The bracteoles, i.e., the secondary bracts within the panicles, are longer than in any other African species of the group (1-4 cm.), and are rigid and erect. They give a characteristically prickly look to the panicles. On drying they become very brittle, and in many older specimens they are almost entirely broken off.

(e) The leaf-like bracts subtending the panicles when fresh stand out ± rigidly from the main stem at an angle of c. 45 degrees above horizontal. This is a character most noticeable in robust specimens in the field. As the stems leaves and bracts are all generally strongly scabrid, walking through a pure stand of tall *S. foliosa* can be a most painful experience.

Distribution

This is the most widespread and abundant species of this group in Africa, having been frequently recorded from Ghana and Ethiopia to the Transvaal. It also grows in Madagascar. It also occurs in India, where, however, records are few (three numbers only at Kew). In at least one case *(Woodrow* 78) it has been confused with the closely allied *S. stocksiana* Boeck., a purely Asiatic species.

3. **Scleria tessellata** Willd., Sp. Pl. **4**: 315 (1805).

Type: Herb. Willd. 17323, Coll. ? *Koenig*, from Eastern India.

S. glandiformis Boeck, in Linnaea **38**: 458 (1874).

Type: *Barter* 1042, from Nigeria.

A species which shows remarkably little variation over its wide range. The following features distinguish it:

(a) The achene is ellipsoid-cylindric, glabrous and shiny. The surface is moderately to lightly lacunose, the lacunae being irregularly oblong and arranged in straight longitudinal rows. Of the walls between the lacunae the longitudinal are always straighter and generally a little higher than the latitudinal. The surface relief is comparable with that of *S. clathrata* or *S. chlorocalyx*.

(b) The disk of the achene is deeply trilobed, and each of the lobes is approximately rectangular, though in some cases the lobe is a little wider at the top than at the bottom. The shape of the top of the lobe is variable, being sometimes rounded, sometimes square, sometimes faintly 2- or 3-pointed.

(c) The lateral panicles are always single at the nodes; their peduncles are invariably stout and erect, and are often hardly exserted from the sheaths. This gives a characteristically strict appearance to the inflorescence. In this it is not unlike *S. foliosa,* though the inflorescence is never as elongated as is usual in that species.

(d) The male spikelets (4-6 mm. long) are pale brown, and markedly longer than their pedicels (0-2, exceptionally 3, mm. long). Generally the male spikelets appear almost or entirely sessile, and this gives a compact look to the panicles.

(e) I have never seen living material of this species, but to judge from recently collected and well-dried specimens that have retained something of their natural colour (e.g. *Milne-Redhead & Taylor* 10149) it would seem that the stems, leaves and bracts are all a pale green, except for some reddish colouring sometimes present at the bases of the lower leaf-sheaths. The panicles also lack the vinaceous colouring frequently to be seen in those of some other species of this group, e.g. *S. clathrata*, *S. parvula* and *S. bambariensis*.

FRENCH SUDAN: Koulikoro, *Chevalier* 2468; Kita Massif, *Jaeger* 1; Bokywere, *Davey* 366.

SENEGAL: Badi, *Berhaut* 1841.

FRENCH GUINEA: Sambailo, Conakry, *Aram* 12716.

NIGERIA: Nupe, *Barter* 1042; Minna, *Meikle* 723a; Zaria, *Taylor* 2624/32; ibid., *Clayton* 1314.

OUBANGUI-CHARI: Bozoum, *Tisserant* 2953.

SUDAN: Bahr el Ghazal, *Schweinfurth* 2389 p.p.; ibid., Rumbek. *Harrison* 1083; ibid., *Davies* B.E.G. 8.

TANGANYIKA: Lindi, *Schlieben* 6404; Songea, *Milne-Redhead & Taylor* 10149.

ANGOLA: Pungo Andongo, *Welwitsch* 7124.

Also in Madagascar (teste Nelmes) and India.

4. **Scleria globonux** C.B.Cl., F.T.A. **8**: 504 (1902).

Type: *Schweinfurth* 2560 p.p., from Sudan; see note on this number below.

The numbers quoted below as representative of this species agree in the following distinguishing characters:

(a) The achene is globose and its surface deeply lacunose. The lacunae are irregularly quadrate to oblong, and are arranged in straight longitudinal rows. The intervening walls are clothed at their tops with short hairs which vary in colour from very pale to bright ferrugineous. Of these walls, the latitudinal are usually, though not invariably, broader than the longitudinal. The latter are always straighter. This is the only African species of this group whose achene is always hairy.

(b) The disk of the achene is deeply trilobed, the lobes being generally like those of *S. tessellata* but usually somewhat shorter and more rounded. However, the shape of the disk is too variable to be a reliable character.

(c) The lateral panicles are almost always single at the nodes, and their peduncles are slender and pendulous. The Kew sheets of *Jordan* 841 and *Noirfalise* 725 each show a plant with one pair of panicles at a node. These exceptions may seem to throw doubt on the validity of this character. Perhaps I may add that I have myself examined hundreds of plants of this species in a number of different localities in the field, and have yet to see a living example with more than one lateral panicle to a node.

(d) The male spikelets are dark reddish- or brownish-black, and are 3-5 mm. long. The pedicels are little shorter or of the same length.

The material of the Type number of this species, *Schweinfurth* 2560, presents some problems. This number is represented by two sheets at Kew. One, to which I shall refer as 2560a, has attached to it a note in Clarke's handwriting as follows:

> "This number *Schweinfurth* 2560 is referred by Boeckeler in Flora 1879 p. 571 to *S. tessellata* Willd., and it is close allied to that; but differs from it more than it does from *clathrata, glandiformis*, etc., and the African set that "represent" *tessellata* in Africa. *Scleria globnux* sp. nova. Type of Species. C. B. Clarke Aug. 1890."

The second sheet, to which I shall refer as 2560b, also has a note in Clarke's hand attached to it. He evidently first wrote "Scleria globonux sp. nova" but subsequently scored through the words "globonux sp. nova" and wrote "glandiformis Boeck." above them.

Schweinfurth 2560a, the sheet which Clarke indicated to be the Type of his new species, bears various broken pieces of plant which unfortunately are not entirely homogeneous. All the material except the piece now mounted on the extreme right of the sheet appears to belong to the species whose characters I have outlined above. But the single piece on the right of this sheet is somewhat different, and seems to me to show signs of hybridity with *S. tessellata*, and I deal with it in my note below, under *S. ? tessellata x globonux*. The plants on *Schweinfurth* 2560b seems to me also to be of the same hybrid origin as the right-hand fragment of 2560a, and these, too, I discuss below.

The only description of *S. globonux* which Clarke ever published was that in the Flora of Tropical Africa vol. VIII. This is not sufficiently detailed to decide how much of *Schweinfurth* 2560a should really be regarded as true Type material. But the hybrid plants, if they are such, should presumably be excluded.

A further complication arises with this number. The figure "2560" on the label of 2560b is not absolutely clear. The "6" is written with so short an upstroke that it looks very much like an "0"; and in fact Clarke seems to have taken the number for 2500. At any rate he quotes "*Schweinfurth* 2500" and not "2560" under *S. glandiformis* in F.T.A. But comparison of the handwriting on the two sheets makes it clear that they are both meant to have the same number, 2560. (Both sheets have the same date, presumably that of collection, "23 Oct. 1869".) Nelmes evidently treated both sheets as having the same number, and wrote on 2560b "S. globonux C.B.Cl.".

The plants on the Paris sheet of this number are similar to the majority of those on 2560a above, i.e., they are all what I call typical *S. globonux.*

SENEGAL: Badi, *Berhaut* 819.

PORTUGUESE GUINEA: Bafata, *Joaquim Viegas da Graça Spirito Santo* 2825.

SIERRA LEONE: Jokibu, *Deighton* 3776; Mateboi, Sanda Tenraran, *Jordan* 841.

LIBERIA: Gbarnga, *Linder* 515.

GHANA: Burufo, *Adams & Akpabla* 4286, 4392a.

NIGERIA: Kontagora, *Dalziel* 238; Minna, *Meikle* 723b.

SUDAN: Bahr el Ghazal, *Schweinfurth* 2560 p.p.

UGANDA: Soroti, *Lind* 369.

BELGIAN CONGO: Elisabethville, *Rogers* 10319a; ibid., *Schmitz* 626; Uele, P.N. Garamba, *Noirfalise* 725; Mosso, Urundi, *Michel* 3306; ibid., *Michel & Reed* 1897.

NORTHERN RHODESIA: Ndola, *Robinson* 2221, 3450, 3681, 3717; Solwezi, *Robinson* 3483; Mwinilunga, *Robinson* 3581.

Not known outside Africa.

Scleria? tessellata x globonux.

The following plants are intermediate in character between *S. tessellata* and *S. globonux*, and it seems possible that they are hybrids. They were all collected within the geographical range of both supposed parent species, and the normal habitat and flowering season of both these are the same. More than this cannot be said at present. It is to be hoped that where collectors find the two species growing together they will look out for intermediate forms.

The following points should be noted in these supposed hybrids:

(a) The achenes are globose and subglobose, and have the surface relief of *S. globonux*. The Angola and Cameroons specimens have glabrous achenes; those of the others are hairy.

(b) The lateral peduncles are erect, stout, and little or not at all exserted from the sheaths, as in *S. tessellata.*

(c) The male spikelets (4-5 mm. long) are notably longer than their pedicels (1-2 mm.), and have the pale colour of those of *S. tessellata.*

GHANA: Achimota, *Adams* 4901; Tamale, *Adams & Akpabla* 4143; *Morton* 6244.

IVORY COAST: Cercle du Baoule, *Chevalier* 22368.

BRITISH CAMEROONS: Vogel Peak Area, *Hepper* 1246.

SUDAN: Bahr el Ghazal, *Schweinfurth* 2560 p.p. (On this number see my note on *S. globonux* above.)

ANGOLA: Pungo Andongo, *Welwitsch* 7123.

5. **Scleria bambariensis** Cherm. in Archiv. Bot. Caen **4**, Mem. **7**: 48 (1931). Syntypeo: *Tisserant* 2693, 2694, from Oubangui-Chari.

Chermezon's original description of this species is curious in many ways. He describes it as a perennial, though examination of the Paris sheets of the two numbers he quotes shows no sign of the rhizome which he asserts is present. He did not include it in the Tessellatae, but considered it closest to *S. substriato-alveolata* De Wild. As his description does not agree with his material in other ways, and as Nelmes reduced the species to synonymy with *S. parvula* Steud., I here give a complete description. It is not based solely on the numbers quoted by Chermezon, but covers the admittedly pretty various material listed below.

An erect, slightly to ± densely caespitose, hairy to almost wholly glabrous annual. *Stems* 20-84 cm. tall, 0.6-2 mm. broad at the base, trigonous, striate, smooth or scabrid on the angles, hairy or glabrous. *Leaves* 1.5-7 mm. broad, hairy on both surfaces or sometimes almost entirely glabrous. *Sheaths* as hairy as the leaves, with the mouth extended into a shortly rounded or almost truncate brownish or semiscarious tongue which is rarely without at least a few hairs and often densely hairy. *Bracts* similar to the leaves; bract-sheaths similar to the leaf-sheaths. *Lateral panicles* 1-3 in each inflorescence, single at the nodes, on slender pendulous peduncles well exserted from the sheaths. *Male spikelets* 3-4 mm. long, pale greenish to dark reddish brown, on pedicels 1-4 mm. long, erect. *Female glumes* 4-5 mm. long, ovate-lanceolate, glabrous or with a few scattered hairs on the midrib, pale straw-coloured or almost scarious, the midrib usually green, the flanks often suffused with green or reddish brown; at times however the whole glume and indeed most of the inflorescence is a uniform deep vinaceous colour. *Achenes* ovate to subglobose, 1.6-2.3 mm. broad, 2-2.2 mm. long (including the disk), white, grey or blackish moderately to deeply lacunose, with the lacunae arranged in ± straight longitudinal rows, the intervening walls glabrous or hairy at the top, the latitudinal ones usually being thicker than the longitudinal; achene shortly beaked. *Disk* 3-lobed, the lobes variable in shape but rounded at the top and usually edged with a scarious margin which may form one or more points to each lobe.

The taxonomic position of the plants which I quote for this species is obscure; and that they all have to each other the same relation as individual members of any other species have to each other is improbable. Their range of variation is very great. They come in some cases very close to *S. parvula*. However, in the latter the lateral panicles are never single at the nodes, as they invariably are in *S. bambariensis*. Some examples also are not easy to distinguish at first from *S. foliosa*, and where the two species grow together they have sometimes been collected together in the name number (e.g. *Miller* 4333, *Robinson* 1674). Its relationship to *S. globonux* is even closer; robust examples of *S. bambariensis* come very near to that species (e.g. the two Milne-Redhead and Taylor numbers from Songea). However, there is a complete series linking these to the much slenderer and altogether different-looking plants of *Bogdan* 3344 and *Robinson* 2155. Moreover, I cannot say from my own experience that these variations within the species are in any way related to differences of habitat.

I suspect that some at least of these plants may prove to be hybrids. Their precise origin, however, must remain a matter for speculation, at least until more evidence of their distribution and association with other related species is available. It seems possible that the smaller specimens, e.g. *Bogdan* 3344, may represent a distinct species, and that the robuster ones are derived from hybrids between that and *S. globonux;* that under changed climatic conditions the range of the supposed parent species *S. globonux* has contracted, leaving the hybrids to perpetuate themselves on their own. This is mere guesswork. I have myself in different places found it growing with *S. foliosa* and *S. gracillima;* with *S. foliosa* and *S. schimperiana;* and with *S. globonux* and *S. schimperiana.*

Chermezon may himself subsequently have had doubts about his species, as he identified a later collection, *Tisserant* 3002, a very good match of the earlier Tisserant numbers which he had quoted for *S. bambariensis*, as *S. clathrata* Hochst. ex A. Rich.

OUBANGUI-CHARI: Yanguya, 40 km. S-E of Bambari, *Tisserant* 2693; Kaga Lekpwa, 7 km. S of Ippy, *Tisserant* 2694; Bozoum, *Tisserant* 3002.

BELGIAN CONGO: Kipopo, 25 km. N-E of Elisabethville, *Schmitz* 3780.

KENYA: 10 miles S-W of Mombasa, *Bogdan* 3344.

TANGANYIKA: Songea, *Milne-Redhead & Taylor* 9902, 9961; Lake Kwela, Ufipa, *Robinson* 1674 p.p.; Tanga Distr., *Peter* 24963.

NORTHERN RHODESIA: Choma Distr., *Robinson* 751, 1254, 1369, 1370, 2150, 2155, 2168, 2169, 2181, 2191, 2199; Kabulamwanda, Namwala Distr., *Robinson* 1103, 1111; Mufulira, *Robinson* 3674; Ndola *Robinson* 3715, 3716, 3719.

SOUTHERN RHODESIA: Makwiro, *Eyles* 2211; Matobo Distr., *Miller* 2749, 4329, 4333 p.p.

Not known outside Africa.

6. **Scleria chlorocalyx** E. A. Robinson, sp. nov.

Type: *Robinson* 4681, Mwinilunga, Northern Rhodesia.

Species *S. clathratae* Hochst. ex. A. Rich, non dissimilis; paniculis lateralibus ad nodos singulis, spiculis masculis brevioribus, achaenio minore, disco poculiformi praecipue differt.

Herba annua, erecta, subdense caespitosa. *Culmi* 12-60 cm. alti, basi 1-1.5 mm. lati, trigoni, striati, inferne laeves, supra in angulis scabridi. *Folia* 2-3 mm. lata, plana, in superficie inferiore parce hirta, in superiore in nervis 2 prominentibus pilosa. *Vaginae* sub ore glabrae, alibi glabrae vel omnino glabrae, ore in linguam brevem convexam pilosam vel glabram paene scariosam producto. *Bracteae* inferiores foliis similes, superiores glabrae; vaginae similes foliorum vaginis. *Paniculi* laterales 1-3 ad nodos singuli, in pedunculis subtilissimis pendulis e vaginis ad 2.5 cm. exsertis; terminalis 1. *Spiculae masculae* 2.5-3 mm. longae, pallide castaneae, in pedicellis 3-6 mm. longis primum erectis demum patentibus vel reflexis. *Glumae femineae* ovatae-lanceolatae, apicibus longe acuminatis; 4-5 mm. longae, glabrae, pallide stramineae vel albidae, carinam versus virides vel rubidae, nervo medio saepius viridi nonnumquam rubido. *Achaenium* ellipsoideum vel late ellipsoideum, 1.5-1.7 mm. latum, 2.5-2.7 mm. longum (disco incluso), glabrum, nitidum, leviter lacunosum, lacunis in lineis rectis longitudinalibus dispositis ubi adultum cinereum, vel pallide cinereum, colore fusciore longitudinaliter distinctum rostro nullo vel vestigiali. *Discus* pallide luridus vel luride viridis, raro obscure 3-lobatus, lobarum conformatione saepius margine pallidiore obscurata, ita ut discus labro integro achaenii partem quartam vel tertiam ut in calice contineat.

Habitat in locis paludosis lateriticis.

NORTHERN RHODESIA: Kawambwa, 1350 m, 21.vi.57, *Robinson* 2321; Kalenda Plain, Matonchi Farm, Mwinilunga, 1400m, 16.iv.60, *Robinson* 3603; Chiwala, Mporokoso, 1400 m., 21.v.1961, *Robinson* 4681 (K, holotype; M; SRGH).

The specific name refers to the pale green cup-shaped disk.

This species has some affinity, as mentioned above, to *S. clathrata*. The achene surface is much the same as in that species; it is also like that of *S. tessellata*. However, the panicles of *S. chlorocalyx* are smaller in all their parts than those of either of these two species. *S. chlorocalyx*

also has some resemblance to the smaller examples of *S. bambariensis*, but from these it is easily distinguished by the achene surface as well as by the small male spikelets and the disk. This latter is larger in relation to the size of the achene than in any of the other African Tessellatae; it holds the achene like an egg in an egg-cup.

7. **Scleria mikawana** Makino in Bot. Mag. Tokyo, **27**: 57 (1913). Type not seen, from Japan.

S. glabroreticulata De Wild., Pl. Bequaert. **4**: 230 (1927). Type: *Vanderyst* 2232, from Belgian Congo.

There appears to be no material in England of Makino's Type, but Japanese specimens at Kew *(Ohwi & Koyama* TSM 961, *Koyama* 75) determined *S. mikawana* at Tokyo are a very good match of the African material given below. This all shows a marked constancy of character. The following points clearly separate this species from the others of this group:

(a) The achenes are ovate to globose in shape. The lacunae are moderately deep, oblong to elliptic and arranged in straight longitudinal lines; not so close as in *S. globonux* or *S. bambariensis,* but rather so that what I have in connexion with those species described as the walls between the lucunae form in this species a ± continuous surface in which the lacunae appear as interruptions (cf. the surface of a golf ball). This surface is dull and often ferrugineous, an appearance caused by the presence of numerous minute and often brownish glands.

(b) The lateral panicles are single at the nodes and are borne on peduncles which are stout, erect and not generally much exserted from the sheaths; exceptionally, however, they may emerge as much as 10 cm. In one or two cases these lateral panicles appear to be in pairs at the nodes, but this is almost certainly an illusion due to the fact that many of the lateral panicles branch low and so when little or not exserted may appear to be double.

(c) The male spikelets are 4-5 mm., exceptionally 3-6 mm. long, and are borne on pedicels 5-14 mm. long. These pedicels are often reddish and of a darker colour than the spikelets. When fully developed they give the panicle a most distinctive appearance, especially when, as usually happens, the lowest ones curve outwards.

(d) The only living plants of the species that I have seen all had a remarkably strict habit, the leaves and bracts being held stiffly erect at a narrow angle to the stems.

SENEGAL: Heudelot 662.

SIERRA LEONE: Nganyahun, *Deighton* 3048; Rokon, Samu, *Jordan* 572; Rokupr, Magbema, *Jordan* 694; Robumbe, Magbema, *Jordan* 803; Madino, Buya-Romende, *Jordan* 913.

FRENCH EQUATORIAL AFRICA: Ndolo, Gabon, *Le Testu* 5844.

BELGIAN CONGO: Wombali, *Vanderyst* 2232; Mosso, Urundi, *Michel & Reed* 280.

NORTHERN RHODESIA: Mwinilunga, *Robinson* 3582.

Also in Asia from India to Japan, and Australasia (Papua).

I have said above that the African specimens quoted above are constant in character. There is, however, an interesting specimen in the Kew Herbarium *(Kurz* 2703) from Ceylon which, while agreeing with typical *S. mikawana* in other characters, has shiny achenes with unusually large lacunae, showing an approach to *S. tessellata*. Such variations should be looked out for in Africa.

8. **Scleria patula** E. A. Robinson, sp. nov.

Type: *Robinson* 3696, Chingola, Northern Rhodesia.

Species *S. parvulae* Steud. affinis; statura exigua, paniculis lateralibus ad nodos singulis in pedunculis erectis e vaginis parum exsertis, habitu submisso praecipue differt.

Herba annua, praeter achaenia omnino glabra. *Culmi* raro erecti, numquam omnino prostrati, saepius inter herbarum robustiorum culmos se insinuantes vel in caespitem subdensum humilem patentes, 3-25 cm. longi, basi c. 1 mm. lati, trigoni, striati, glabri. *Folia* plerumque valde reducta, ± plana, 1-2 mm. lata, glabra. *Vaginae* glabrae, basales rubescentes, ore in linguam brevem convexam producto. *Bracteae* laterales longe culmum, caepe etiam bracteam supremam excedentes, usque ad 23 cm. longae, ± planae, glabrae, 1.5-3 mm. latae. *Paniculi* 1-2 cm. longi, laterales 1-2 ad nodos singuli, in pedunculis subrobustis erectis non vel breviter e vaginis exsertis. *Spiculae masculae* c. 2 mm. longae, stramineae vel pallide rubidae, in pedicellis 1.5-3 mm. longis. *Glumae femineae* ovatae-lanceolatae, 3-4 mm. longae, glabrae, apicibus longe acuminatis, plerumque pallide stramineae vel paene scariosae, virides vel rubidae carinam versus, nonnumquam totae rubidae, nervo medio semper viridi vel rubido. *Achaenium* ovatum vel subglobosum, 1.2-1.4 mm. latum, 1.8-2.0 mm. longum (disco incluso), hirtum vel glabrum, superficie lacunosa, lacunis oblongis vel subquadratis in lineis rectis longitudinalibus dispositis, breviter rostratum. *Discus* pallide viridis, trilobatus, lobis saepe apicem versus margine albido vel scarioso in apiculas 1-3 producto circumdatis.

Habitat in locis paludosis.

NORTHERN RHODESIA: Kalenda Plain, Matonchi Farm, Mwinilunga, 1400m, 16.iv.60, *Robinson* 3589, 3684; Banks of Kafue River, 11 km. North of Chingola, 135m, 4.v.60, *Robinson* 3696 (Holotype K; Isotypes SRGH; M).

The following characters should be noted in this species:

(a) It is much the smallest of the African *Tessellatae*, both in stature and in parts. Robust examples of it might perhaps be taken (if certain important details are ignored) for very small specimens of *S. bambariensis* or *S. parvula*. I feel sure, however, that the small size of the plants described above is not due to peculiarities of habitat. They are not merely depauperate specimens of another normally robuster species. In both its localities it grew abundantly over a wide area, and the range of variation within each community could easily be judged. This range is indicated in the specimens chosen for the holotype.

(b) In the Type number (3696) all the achenes examined were hairy. That collection consisted of 56 separate plants, on each of which a few achenes were looked at. I cannot positively assert that there are no glabrous achenes in this number. The two other numbers quoted really formed a single community; only after collection did I divide the material into two numbers, 3589 with hairy and 3684 with glabrous achenes. The first number consisted of 114 plants, the second of 61. These were examined in the same way as those of the Type number, and the same reservation must be made. It may be of interest to compare the relative frequency of plants with hairy and plants with glabrous achenes in these gatherings with that in two other species whose achenes vary in this way. Of the 28 sheets of *S. parvula* (from Asia and Africa) examined by me at Kew, 19 had hairy achenes, 9 glabrous. Of the 18 numbers of *S. bambariensis* collected by myself in Northern Rhodesia 13 have hairy achenes, 5 glabrous. The evidence available is of course too scanty for any worthwhile conclusion to be drawn from these figures; but they may be held to indicate a tendency.

(c) Making allowances for the difference in size, the surface relief of the achene in this species is very similar to that in *S. parvula* and *S. bambariensis*. The same is true of the disk.

(d) The lateral panicles are invariably single at the nodes; and their peduncles are, for a plant of this size, stout, and always erect.

(e) The male spikelets are smaller than in any other African species of the group, and their pedicels are usually, though not always, longer than themselves.

(f) As in most of the Tessellatae, the distinction between leaves and bracts is rather an artificial one. In this species the true leaves are usually very few, and their blades are often reduced to a length of a few mm. The bracts, however, are very well developed, perhaps more so in relation to the size of the plant than in any other of the African species. The topmost bract is rarely long, but the others generally far exceed the stem. It was noticeable that, in situations which encouraged robuster growth (e.g. where *Rhynchospora perrieri* Cherm., a close associate of No. 3696, reached the extraordinary stem-length of 74 cm.) it was the bracts rather than the stems of *S. patula* that showed the greatest increase in size.

9. **Scleria hildebrandtii** Boeck. in Flora, **63**: 454 (1880). Type: *Hildebrandt* 2044, from Kenya.

This species is only known from two collections, which show some variation. However, they agree in the following characters:

(a) The achene is bluntly trigonous in section, more markedly so than in any other African species of this group. Longitudinally it is oblong to cylindric. The surface is glabrous and lightly alveolate, generally less so below and more markedly so towards the apex.

(b) The disk is barely 3-lobed, and it is uniformly reddish above.

(c) The lateral panicles are single or in pairs at each node, each stem showing at least one pair. Their peduncles are stout, erect and, where they are in pairs, very unequally exserted.

(d) The male spikelets are a light brown, 4-5 mm. long in the Kenya specimens, 5-6 mm. in the Madagascar ones. The male pedicels are 1-3 mm. long, except for one example from Madagascar which is 5 mm.

KENYA: Mombasa, *Hildebrandt* 2044.

Also known from Madagascar (*Perrier de la Bathie* 11252).

10. **Scleria gracillima** Boeck, in Flora, **62**: 570 (1879). Type: *Schweinfurth* Ser. 3, 189, from Sudan.

This is the most slender of the African *Tessellatae*. It is so inconspicuous when growing among other stouter vegetation that it may well be more common than its records suggest. It is easily distinguished from the others by these characters:

(a) The achene is oblong-cylindric, smooth and shining, whitish or grey, often with blackish longitudinal stripes which start a little above the disk and stop below the apex.

(b) The disk is not or only faintly 3-lobed.

(c) The lateral panicles are single or in pairs at each node, every plant having at least one pair. The peduncles are filiform, so slender as to be practically unmeasurable (0.1 mm. ?), and pendulous.

(d) The entire plant is glabrous, the only African species of this group to be so, with the exception of the glabrous-nutted forms of *S. patula*.

GHANA: Ejura Scarp, Ashanti: *Morton* GC 9630, 9707.

SUDAN: Bahr el Ghazal, *Schweinfurth* Ser. 3, 189.

TANGANYIKA: Songea, *Milne-Redhead & Taylor* 10477.

NORTHERN RHODESIA: Mapanza, Choma, *Robinson* 2151, 2840.

Dr. Morton tells me that *S. gracillima* has been collected a number of times in Ghana. I have only seen the specimens quoted.

Not known outside Africa.

11. **Scleria clathrata** Hochst. ex A. Rich., Tent. Fl. Abyss. **2**: 510 (1851).

Type: *Schimper* 1603, from Ethiopia.

A species easily distinguished by the following characters:

(a) The achenes are glabrous and similar in surface relief to those of *S. tessellata;* in shape they are more nearly cylindrical and less elliptical.

(b) The disk of the achene is hardly at all trilobed, and it itself is supported on a short stipe. This is a most peculiar feature, not paralleled in any of the other species dealt with here. (In some immature examples of other species premature shrivelling of the disk may leave a stipe-like appendage, but this cannot be compared with the stipe of *S. clathrata.)*

(c) The lateral panicles are 1-3 at each node, no plants having all their panicles single. The peduncles are slender, pendulous and well exserted from the sheaths.

(d) The male spikelets are 3-4 mm. long, on pedicels 2-5 mm., exceptionally 7 mm. long. (Immature examples, e.g. Schimper 1271, may have their male spikelets almost sessile.)

Like many others of the group, this is a most inconspicuous plant, and the records below may give little idea of its true distribution. The Northern Rhodesian plants quoted differ in some points from the Ethiopian, on which Nelmes' excellent description is based. They are up to 60 cm. tall, and their leaves are narrower (—3 mm.) and by no means glabrous on either surface. However, in all important points they agree with the others.

ETHIOPIA: Walcha, *Schimper* 1603; Gafat, *Schimper* 1271; Begemeder, Senka Berr, *Schimper* 1236; Woliss, *Mooney* 5852b.

NORTHERN RHODESIA: Mwinilunga, *Robinson* 3617.

Not known outside Africa.

12. **Scleria parvula** Steud., Syn. Pl. Glum. **2**, Cyper. 174 (1855).

Type: *Hohenacker* 1295, from India.

S. uliginosa Hochst. ex Boeck. in Linnaea, **38**: 471 (1874).

Type as for *S. parvula* Steud.

S. fenestrata Franch. et. Savat., Enum. Pl. Japon. **2**: 122, 579 (1879). No Type.

The type number, Hohenacker 1295, is represented by poor material on both the Kew and British Museum sheets. The plants are small and immature, and on most of them the lateral panicles seem to be single at the nodes. However, the sheets at Paris and Uppsala show clear examples of pairs of lateral panicles, and I have no doubt that dissection of all the material of this number would show that few if any of the lateral panicles were single. Apart from this feature there is little to separate *S. parvula* from slender examples of *S. bambariensis*, a species which Nelmes considered synonymous. *S. schmitzii* Piérart was also held by Nelmes to be a synonym of *S. parvula*. That species was based on a single immature gathering of *S. nyasensis* C.B.Cl. (Schmitz 3115). Nelmes' attempt to accommodate *S. schmitzii* in *S. parvula* led him to describe the latter species as having "stem-bases sometimes becoming bulbously thickened". This character is of course typical of the perennial *S. nyasensis*, but not of the annual *S. parvula*. Of the eleven numbers quoted by Nelmes for *S. parvula* seven are *S. bambariensis* (q.v.) and three (Schmitz 3115, Tisserant 2971 and Germain 1833) are *S. nyasensis*. This leaves Jones 204, quoted below, as the only certain record of *S. parvula* in Africa. It may well be considered doubtfully native here, having possibly, as Mr. J. P. M. Brenan has suggested, been introduced with rice seed into Sierra Leone. However, its true relationship with the very similar plants described above as *S. bambariensis* may require reappraisal.

The following points should be observed in *S. parvula*:

(a) The achene is, to me, indistinguishable from that of some examples of *S. bambariensis*, though in general it is much less variable, and never attains a length of 3 mm. The surface relief is similar. Nelmes' statement that it is hairy is an error, though it happened to be true of the mixed bag of specimens which he included in the species. It is only sometimes so. For the relative frequency of plants with hairy and glabrous achenes see my note (b) under *S. patula*.

(b) The disk is 3-lobed, but, as in *S. bambariensis*, the shape of the lobes is not constant.

(c) The lateral panicles are almost always 2-3, exceptionally 4 or 5, at the nodes. Occasional plants may be found with one single lateral panicle, but in no mature example of the plentiful Asiatic material of this species at Kew and the British Museum is there a single plant with all its lateral panicles single.

(d) The male spikelets are 3-4 mm., exceptionally 5 mm. long, pale or dark brown, on pedicels 1-3 mm. long.

SIERRA LEONE: Picket Hill, *Jones* 204.

Widely distributed in Asia from India to Japan and the Philippines; also, teste Nelmes, in Madagascar, but I have seen no specimens from there.

DOUBTFULLY RECORDED SPECIES

Scleria biflora Roxb.

Of this common Asiatic species I have seen no material from Africa. However, Piérart (*Lejeunia*, Mém. **13**: 44 (1951)) attributes to it, with some doubt, three numbers from the Belgian Congo, which I have not seen. It is not clear from his description whether they are annuals or perennials.

The following characters of *S. biflora* should suffice to distinguish it from any African species:

(a) The achene is globose or flattened-globose. At the apex it is flattened or even depressed, and it has a well-marked beak which is generally purple or blackish. The lacunae are clear-cut, deep, square or broader than they are long, never longitudinally elongate. The walls between the lacunae are all of equal width, and are always clothed with pale to ferrugineous hairs. These achene characters are not all adequately shown in the drawing in Clarke's "Illustrations of Cyperaceae" (1909), p. 127, to which Pierart refers, nor in his own drawing (1.c., Pl. 2m fig. 11).

(b) The three lobes of the disk are elongate and sharply acuminate.

(c) The lateral panicles show more variation than in any African species of this group. They are generally single at the nodes except for the top node which may have two panicles. However, in robust plants the lower nodes may also have two panicles at each.

(d) The lateral peduncles are erect and fairly stout; certainly stouter than in *S. parvula*.

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NOTES ON THE GENUS THILACHIUM

by

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ON THE CORRECT SPELLING OF THE NAME THILACHIUM*

The genus Thilachium was published with this spelling by Loureiro at p. 342 of the "Flora Cochinchinensis", printed at Ulyssipone (= Lisbon) in 1790. The name is so spelled in the generic heading on that page, in the Index (p. 720) and in the Table of Contents for "Classis XIII, Polyandria Monogynia" (p. 328). It was published with the same spelling in the reprint edition edited by Willdenow published in Berlin in 1793 (vol. 1: 417-418 and vol. 2: 880). The name was also used with this spelling (contrary to the reference in Fl. Zamb. 1 (1): 213 (1960)) by Jussieu in Ann. Mus. Nat. Hist. Nat. (Paris) 2: 70-71 (1808). It was so spelled by J. E. Smith in Rees Cyclopedia (1817).

Some confusion seems to have been caused because, in his specific description, Loureiro spelled the name Thilakium. It seems clear, from an examination of the rest of the "Flora . . .", that Loureiro frequently transliterated the Greek after the spoken fashion of his native language, Portuguese. It is true that the Greek upsilon is generally transliterated as "y" in northern European practice. In modern Portuguese "y" is much in evidence as a transliteration of the Greek upsilon, but older transliterations have "i" instead, so it appears that "y" and "i" are orthographic equivalents. Therefore, Loureiro's use of "i' must be treated as his deliberate choice of spelling. His usage of "i" is consistent in all spellings, therefore it cannot be considered an orthographic error and must not be corrected.

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* In the interests of the free discussion of nomenclatural matters the editor of KIRKIA is glad of the opportunity of publishing Dr. G. P. DeWolf's opinion on the correct spelling of this genus. However, in the preparation of the account of the Capparidaceae for the *Flora Zambesiaca* (Vol. 1, 1: 213 (1960)) considerable thought was given to this orthographic problem by the authors of this footnote. They have now re-examined the position in the light of Dr. DeWolf's conclusions and they still remain of the same opinion as before. The main points of their argument are as follows:

(i) It is true that one Loureiro version "THILACHIUM" does preponderate but this has no force as an argument here. In the first place it leads to what we consider an "impossible" solution and secondly it would only have real force if, as is sometimes the case with Linnaeus, for example, an error was made in the Species Plantarum, ed. 1 and was subsequently consistently corrected in later Linnaean works.

(ii) As Loureiro has two different forms both of which contain orthographic errors and as he gives the Greek derivation of his name then a correction has to be made in any case and this gives an opportunity to make a correct transliteration as follows:—
(a) Loureiro's "I" was an incorrect transliteration of the Greek which is always transliterated as "Y".
(b) κ cannot be turned into "CH", the correct latinization is to "C".

(iii) *"Thylacium"* is already in common use through the *Flora Zombesiaca.* It would be a pity to change this spelling unnecessarily.

—J. E. Dandy, A. W. Exell, W. T. Stearn and H. Wild.

In a similar manner, "ch" has, in the past at least, been used for the "k" sound, particularly in words of Greek origin, so that "k" (or hard "c") and "ch" may be considered in this context as orthographic equivalents (cf. Richardson, Pereira and Pereira, Modern Portuguese-English, English-Portuguese Dictionary, McKay, Philadelphia, 1943, p. 10, and also Michaelis, A New Dictionary of the Portuguese and English Languages . . . , 1883, vol. 1, pp. 118 and 157). One may further note that the "ch", though unusual is not unknown in Latin as a substitute for the hard "c" (cf. pulcher and pulcer). "K" is, in any event, foreign to both Latin and Portuguese. Whether or not "ch" is acceptable in Portuguese, it seems to be so in Latin. Again, Loureiro's nearly consistent usage must be considered as his deliberate choice, and the "k" may be treated as an orthographic error (or a typographic error !) which was corrected by the original author.

In his edition of the "Flora . . ." of 1793 Willdenow corrected the variation "Thilakium" to "Thilachium" and there the matter should have ended. K. Sprengel, however, in 1818 (Anleit. Kenntn. Gewachse, ed. 2, 2(2): 776) "corrected" the spelling to Thylacium (which in Portuguese would be pronounced "Thilasium", cf. Michaelis, 1:118). This spelling has never had a great deal of currency, though it has recently been revived in Flora Zambesiaca 1 (1): 213 - 214 (1960). DeCandolle in 1824 (Prod. Syst. Nat. 1:254) spelled the name "Thylachium", and this spelling has been used by most subsequent authors. Indeed, if custom and general usage had any weight in matters of this nature, then this is the spelling that should be used. In summary, Loureiro seems frequently to have transliterated his Greek into a Portuguese form, and treated it as Latin, an unorthodox procedure to be sure by northern European standards, but one which is certainly not contrary to the Code (Art. 20 states "The name of a genus . . . may be taken from any source whatever, and may even be composed in an absolutely arbitrary manner.").

There are, thoughout the "Flora Cochinchinensis", a number of apparently typographical errors in the generic headings. These are frequently corrected either in the index or on the errata sheet. Examples of these are Evonymys = Evonymus; Perriploca = Periploca; and Grmmica = Grammica. There remains, however, a residue of names which, like Thilachium, though incorrectly or peculiarly formed or spelled by modern northern European standards, seem to have been deliberately so treated by Loureiro. One outstanding example of such a seemingly inexplicable error is "Equicetum", but this seems to be a deliberate correction into Portuguese form on Loureiro's part, since an "s" between two vowels sounds like "z" in Portuguese. A true error seems to be Thrixspermum. This should, of course, be Trichospermum. Bentham considered this name to be so barbarously formed that he refused to admit it to the "Genera Plantarum" (Journ. Linn. Soc. 18(110): 333 (1881); Fl. Australiensis 6:292 (1873)). If this be "corrected" it must antedate the Trichospermum of Blume by 38 years. I leave it to the imagination of the reader to infer the confusion that such an act would bring into the horticultural literature of the Orchidaceae. A very similar example to that of Thilachium is Enkianthus. This has been twice "corrected", once by K. Sprengel to Encyanthus, and again by DeCandolle to Enkyanthus, but neither spelling seems to have modern currency. The Preamble to the Code states in part ". . . The purpose of giving a name to a taxonomic group is not to indicate its character or history, but to supply a means of referring to it . . . This Code aims at the provision of a stable method of naming taxonomic groups . . . Other considerations, such as absolute grammatical correctness, regularity or euphony of names . . . notwithstanding their undeniable importance, are relatively accessory."

Article 73 states in part "The original spelling of a name or epithet must be retained, except that typographic or orthographic errors should be corrected . . . Note 4. The liberty of correcting a name must be used with reserve, especially if the change affects the first syllable . . .". Article 70 of the 1935 edition of the Rules included the phrase ". . . a clearly unintentional orthographic error." Article 73, Example 1, of the present Code clearly indicates that the *deliberate spelling* of the original author must be followed, however "incorrect" it may be. However unorthodox Loureiro may have been in his transliterations, by our standards, he was certainly deliberate in his transcriptions into Portuguese form. Even where he made demonstrable errors, as Thrixspermum, the "correction" of his deliberate spelling at this late date would certainly upset established custom and throw the science into confusion. Thilachium is not an important genus botanically or horticulturally, but if we "correct" its spelling we are equally bound to "correct" Thrixspermum and Enkianthus, both of which have a relatively wide contemporary currency. The names as they were deliberately published conform completely with the requirements of the Code. I wish to thank Mr. H. K. Airy-Shaw, Royal Botanic Gardens, Kew, and Dr. L. del Rebelo, King's College, London, for their advice on the linguistic points.

It is abundantly clear that there is no typographical or orthographical error involved in the spelling "Thilachium". It is therefore clear that, despite the various attempts at "correction", enumerated below, the correct spelling of the name is the original one.

"Thylacium" K. Sprengel, Anleit. Kenntn. Gewachse, ed. 2, **2**, 2: 776 (1818); Sprengel, Syst. Veg. **2**: 606 (1825); Dietrich, Syn. Pl. **3**: 269 (1843).

"*Thylachium*" DC. Prod. **1**: 254 (1824); G. Don, Gen. Syst. **1**: 286 (1831); Meisner, Gen. Pl.: 17 (1837); Endlicher, Gen. Pl.: 892 (1839); Bentham & Hooker, Gen. Pl. **1**, 1: 107 (1862); Engler & Prantl, Pflanzenfam. **3**, 2: 235 (1891) and ed. 2 **17b**: 201 (1936).

"*Thylaucium*" Dietrich, Syn. Pl. III: 212 (1843).

NOTES ON THE AFRICAN SPECIES

Thilachium Loureiro is a shrubby Capparidaceous genus of possibly ten species native principally on Madagascar, with four species on the East African Coast from Transvaal to Somaliland. One species *T. africanum* seems to be common to the mainland and to the island.

The genus is immediately distinguished from all other genera of the Capparidaceae by its circumscissile, calyptriform, calyx. This remarkable character is, so far as I know, found nowhere else in the family. The cylindrical, longitudinally ridged ovary, with six or more elongate parietal placentae, however, is similar to that of *Capparis erythrocarpos* and *C. cartilaginea* on the one hand, and to the genus *Morisonia* and certain species of so-called *Capparis*, section *Colicodendron*, of the American tropics, on the other.

Of the four East African species, one, *Thilachium africanum*, ranges, in dry country, from the Kenya Coast to Transvaal, and inland, to Lake Rudolph and south-eastern Lake Victoria. It is extremely variable vegetatively, particularly in leaflet shape and number.

The other three species are primarily East Tropical African endemics with rather limited distributions. *Thilachium paradoxum* with elongate petioles and very small unifoliolate lamina, is now known only from a few collections from the area around Lindi in Tanganyika. The primary syntype "Kirk, s.n.", has been quoted as coming from "opposite Zanzibar Island". This seems a little suspect since all of the other collections are from the area around and behind Lindi. There is no collector's data with the Kirk specimen, which consists of a flowering twig about 10 cm. long, with five detached leaves, but the following note is written, in Oliver's hand, on the type sheet: "In a parcel of plants rec'd 3/78 from Dr. Kirk coll'd in part opposite Zanzibar Isl. by himself, in part by Bp. Steere in Nyassa".

Bishop Edward Steere (cf. Dict. Nat. Biogr.) was an Anglican missionary based on Zanzibar. Beginning in 1875 he made two trips, one to Mwembe, in the Nyassa district of Mozambique on a southern branch of the Rovuma River (Aug. 1875-Feb. 1876), and the other to Masasi (later in 1876-Jan. 1877), a district and mission station (which he founded) in the area behind Lindi. I am inclined to think, on the basis of present data, that the primary syntype of *T. paradoxum* was collected by Bishop Steere in extreme southern Tanganyika or northern Mozambique, and that the species is endemic in that area.

Thilachium densiflorum is an equally poorly known species from the area between Dar-es-Salaam and Morogoro. Finally, *T. Thomasii* ranges on the coast from Mombasa into Somaliland and inland to Voi and the Mutha Plains. *T. densiflorum* seems to be similar to some of the species of Madagascar, but *T. paradoxum* and *T. Thomasii* are both probably extreme and discrete variants from *T. africanum* and are both very poorly understood. Fruiting material of both *T. paradoxum* and *T. densiflorum* is lacking in the Kew Herbarium.

The four species of Thylachium in Continental Africa can be discriminated as follows.

Inflorescence generally 10-20 flowered, flower-bud up to 5.5 mm. in diameter, anthers 1-1.5 mm. long *T. densiflorum*

Inflorescence usually 1-10 flowered, flower-bud 6-8 mm. in diameter, anthers about 3 mm. long 2

2. Petioles 8-30 cm. long bearing small simple leaflets, leaflets frequently absent, the petioles then simulating terete leaves *T. paradoxum*

Petioles to 7 cm. long, or much shorter 3

3. Leaves variable in shape and size but always having some trifoliolate leaves present, petiole 4-70 mm. long. *T. africanum*

Leaves always simple, petioles 5-9 (—14) mm. long *T. Thomasii*

THE FOLLOWING NOTE WAS LEFT BY MISS ELFFERS WITH HER MANUSCRIPT OF THILACHIUM FOR THE FLORA OF EAST TROPICAL AFRICA

T. Thomasii Gilg in Engl., Bot. Jahrb. **33**: 229 (1903); Gilg et Benedict in Engl., Bot. Jahrb. **53**: 264 (1915). T. Mildbraedii Gilg in Wiss. Ergebn. Deutsch. Zentr.—Afr.—Exped. 1907-8: 219 (1911).

In their key to the species of Thilachium, Gilg and Benedict separate *T. Thomasii* from *T. Mildbraedii* by means of differences in leaf-shape and in the indumentum of leaves and branches. *T. Thomasii* is stated to have glabrous leaves and branches but this is not borne out by examination of the holotype (*Thomas* 138) which has papilla-like hairs very similar in character to those found on the holotype of *T. Mildbraedii* (*Mildbraed* 17) though somewhat shorter and very much sparser. As for differences in leaf-shape, with the material now available for comparison, it is soon apparent that there are many intermediates between the orbicular or suborbicular leaves with obtuse or emarginate spices of *T. Mildbraedii* and the ovate or ovate-orbicular leaves with acute and apiculate apices of *T. Thomasii*, and it has proved impossible to separate them according to the key-characters. It seems, therefore, that the plants should be regarded rather as all belonging to one variable species and *T. Mildbraedii* should be reduced to a synonym of *T. Thomasii*.

SOME NOTES ON THE VEGETATION OF A PORTION OF THE WANKIE NATIONAL PARK

by

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INTRODUCTION

Information concerning the vegetation of any area is a basic essential to the study of any wild life, vertebrate or invertebrate, within it. It is largely the vegetation which comprises the habitat in which the animals live, breed and seek refuge, and all animals are ultimately dependent directly or indirectly on certain plants for their food. The distribution of plant species and associations, the vital habitat, is of great importance therefore not only to the presence or absence of species within the region but also in the diurnal and seasonal movements which individuals or groups of animals undertake.

I was very fortunate during October and November, 1959, to have the opportunity of spending several weeks with Thane Riney, Fulbright research scholar, who is carrying out research on large mammals in Southern Rhodesia. Whilst working in the Wankie National Park, Riney has been carrying out an intensive study of the distribution and movements of game animals in the area known as the 10-mile drive in the vicinity of Main Camp. It was therefore decided to prepare a vegetation map of this area.

ACKNOWLEDGEMENTS

The survey was undertaken on the suggestion of Mr. Thane Riney and the writer is indebted to him for his helpful interest and criticism. Mrs. P. A. Riney has very kindly prepared the published map from the original sketch. Mr. and Mrs. Riney, and Dr. D. Clark have all read through, and criticized the manuscript. The writer is also indebted to Mr. E. Davison, Chief Game Warden of the Federal National Parks Department, for providing facilities to work in the area and to him and to Mr. Bruce Austen for much information on the history of the area. Mr. Armitage, Conservator of Forests, Matabeleland, has kindly identified some of the trees and shrubs, and Mr. D. B. Fanshawe, Senior Research Officer, Northern Rhodesia Forestry Department, has checked the nomenclature. We are also grateful to Messrs. Aerial Surveys of Rhodesia for permission to publish a copy of the aerial photograph from which the map was produced.

GENERAL DESCRIPTION OF THE AREA

The 10-mile drive is a game viewing tourist road forming a loop on the western side of the Main Camp near Dett. The area is a slight depression about four miles by one mile surrounded by low ridges of Kalahari sand. Even in years of excessive rainfall there is no surface drainage out of the depression (oral communication, Davison, Nov., 1959). Temporary pans and permanent waterholes tend to be arranged around the periphery of the basin along the foot of the surrounding rising country. Game is attracted to this area for water and also for browsing and grazing as several very palatable species of trees and shrubs are among the available dominants. A further advantage from the tourist aspect is that visibility is good owing to the more open nature of much of the vegetation as compared with the surrounding Kalahari sand woodland.

METHODS

Sample sites were selected largely to coincide with those already used by Riney in his study of animal habitat using line point transects to obtain more detailed information on habitat and animal density and conservation values. In two cases, lines Nos. 14 and 15, Riney's conservation line had been put down in open grassland from the immediate vicinity of which trees and shrubs were absent. In these instances the tree count was made along the bush fringe in the vicinity.

Figure 1 is a sketch map of the 10-mile drive showing positions of the various sample lines.

At each site, without conscious selection, a sample of approximately 100 woody plants was classified into species. The information thus recorded was plotted on to a map prepared from air photographs made by Messrs. Fairey Aerial Surveys of Rhodesia. This information was checked by a number of surface traverses and is present as Figure 2.

TYPE 1 — KALAHARI SAND WOODLAND

This vegetation covers very extensive areas entirely surrounding the 10-mile drive. Broad, somewhat low, well-drained ridges of deep sand characterize the terrain. The main components of the vegetation are *Terminalia sericea* Burch.; *Baikiaea plurijuga* Harms; *Erythrophleum africanum* (Welw. ex Benth.) Harms; *Pterocarpus angolensis* DC.; and *Giubourtia coleosperma* (Benth.) J. Léonard, all of which assume local dominance within the main woodland. Other common species present include *Ochna pulchra* Hook.; *Strychnos pungens* Solered;. *Diplorhynchus condylocarpon* (Muell. Arg.) Pichon; with *Baphia obovata* Schinz; and the poisonous undershrub *Dichapetalum cymosum* (Hook.) Engl.

The trees in this association are well grown, 25-40 feet in height; in some places forming almost a closed woodland.

TYPE 1A — AREAS OF YOUNG SAPLINGS OF KALAHARI SAND SPECIES

The chief characteristic of this type is the uniformity in size of the usually rather dense stand of young trees and shrubs. Mature trees of a height of over 12 feet are either scarce or altogether absent. Many of the saplings particularly of *Erythrophleum* are growing in clumps.

The species composition of five sample lines is as follows:—

Sample Line No.	*8*	*10*	*15*	*16*	*17*	*Total*	*Mean %*
Acacia giraffae Burch.	—	—	13	—	—	13	2·6
Baikiaea plurijuga Harms	1	—	—	—	—	1	0·2
Burkea africana Hook.	20	15	35	11	11	92	18·4
Combretum hereroense Schinz	2	7	—	—	—	9	1·8
C. zeyheri Sond.	16	6	4	13	19	58	11·6
Dichapetalum cymosum (Hook.) Engl.	1	—	—	4	—	5	1·0
Diplorhynchus condylocarpon Pichon	11	—	—	4	—	15	3·0
Erythropleum africanum (Welw. ex Benth.) Harms	29	20	—	30	28	107	21·4
Euclea sp.	3	—	—	—	—	3	0·6
Ochna pulchra Hook.	—	—	—	7	16	23	4·6
O. sp. (dwarf)	—	—	—	6	3	9	1·8
Peltophorum africanum Sond.	2	2	1	—	—	5	1·0
Pseudolachnostylis maprouneifolia Pax	1	8	—	5	—	14	2·8
Terminalia mollis Laws.	12	—	6	—	—	18	3·6
T. sericea, Burch.	—	42	41	20	23	126	25·2
Unidentified	2	—	—	—	—	2	0·4
TOTAL	100	100	100	100	100	500	100·0

The sites of sample lines Nos. 8, 10, 16 and 17, are all very similar with a very dense stand of shrubs reducing visibility to only a few yards. The height of the plants in line No. 17 averages some three feet higher than that of the sample 16 immediately adjacent across the road, as a result of protection from fire for the past seven years (B. Austen, oral communication November, 1959).

This regeneration is killed back in some years by heavy frosts (Davison, oral communication).

Sample line 15 differs from the other in that encroachment is on a very much smaller scale. Woody plants are very much smaller and more sparsely distributed.

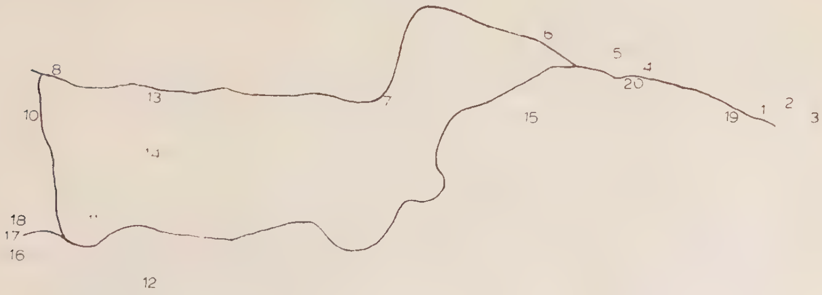


Figure 1.—Location of sample transects.

TYPE 2 — COMBRETUM WOODLAND

The Combretum woodland occupies the better drained portions of the floor of a basin which lies within the Kalahari Sand woodland proper. The poorly drained areas tend to be grasslands.

The species composition of three samples is as follows:—

Sample Line No.	*4*	*5*	*6*	*Total*	*Mean %*
Acacia galpinii Burtt Davy	—	4	—	4	1·3
A. giraffae Burch.	1	10	12	23	7·7
Burkea africana Hook.	—	1	—	1	0·3
Combretum hereroense Schinz	48	62	53	163	54·3
C. imberbe Engl. & Diels	—	11	—	11	3·7
Commiphora sp.	—	1	—	1	0·3
Dichrostachys cinerea (L.) Wight & Arn.	1	1	3	5	1·7
Diospyros lycioides Desf.	—	—	2	2	0·7
Grewia sp.	3	—	1	4	1·3
Maytenus senegalensis (Lam.) Exell	1	1	—	2	0·7
Lonchocarpus capassa Rolfe	—	5	—	5	1·7
Peltophorum africanum Sond.	12	2	7	21	7·0
Rhus sp.	34	2	14	50	16·7
Terminalia sericea Burch.	—	—	3	3	1·0
TOTAL	100	100	100	300	100·1

The main canopy is between 20 and 30 feet and the stand of *Combretum hereroense* is relatively dense. No mature *Guibourtia* were seen in this association. All the specimens counted in sample line No. 6 were below three feet in height. The shrub *Diospyros lycioides* is common on the ecotone between the *Combretum* woodland and the grasslands and vleis.

TYPE 2A — AREAS OF *DIOSPYROS LYCIOIDES AND* YOUNG SAPLINGS FROM THE COMBRETUM WOODLAND ASSOCIATION

This zone of scrubby bush is distributed from the edge of the *Combretum* woodlands encroaching into the grassland of the vleis. The better developed areas of this vegetation are distributed on the better-drained patches of soil. Six sample lines were taken and the species composition found to be as follows:—

Sample Line No.	*7*	*11*	*12*	*13*	*14*	*18*	*Total*	*Mean %*
Acacia galpinii Burtt Davy .	—	1	4	—	1	1	7	1·1
A. giraffae Burch. . . .	2	—	25	1	—	18	46	7·3
Colophospermum mopane Kirk ex J. Léonard . .	—	—	—	3	—	—	3	0·5
Combretum hereroense Schinz	1	6	17	11	17	2	54	8·58
C. imberbe Engl. & Diels .	1	—	—	6	31	4	42	6·68
C. zeyheri Sond. . . .	—	—	—	—	—	5	5	0·79
Dalbergia melanoxylon Guill. & Perr.	—	—	—	54	—	—	54	8·58
Dichrostachys cinerea (L.) Wight & Arn. . . .	—	—	—	—	1	—	1	0·15
Diospyros lycioides Desf. .	81	92	42	21	47	47	330	52·46
Erythrophleum africanum (Welw. ex Benth.) Harms	—	—	—	2	—	—	2	0·32
Euclea sp.	—	—	—	2	—	—	2	0·32
Grewia sp.	—	—	—	1	5	—	6	0·95
Maytenus senegalensis (Lam.) Exell	14	—	8	—	7	—	29	4·6
Lonchocarpus capassa Rolfe	—	—	—	2	—	2	4	0·6
Peltophorum africanum Sond.	—	—	2	4	—	3	9	1·43
Rhus sp.	—	—	1	1	—	—	2	0·32
Terminalia moliis Laws. .	—	—	—	11	—	—	11	1·75
T. sericea Burch. . . .	1	—	—	—	—	17	18	2·86
Ziziphus mucronata Willd. .	—	1	—	—	—	1	2	0·32
Unidentified	—	—	—	2	—	—	2	0·32
TOTAL . . .	100	100	99	121	109	100	629	99·93

The only large trees in these samples are a few *Combretum* spp. and *Acacia* spp., but the majority even of these species are small immature plants. The shrub *Diospyros lycioides* covers a very high proportion of the area and this species together with *Acacia giraffae, Combretum hereroense, C. imberbe, Maytenus* and *Dalbergia* comprise over 88 per cent. of the total woody vegetation.

Sample lines No. 13 at the four-mile point and No. 18 off the Nyamandhlovu road are both adjacent to areas of type 1A and contain elements of the Kalahari sand flora such as *Terminalia.*

This association is very patchy in distribution and forms a fine mosaic with the grassland on the one hand and mixes in some places with the more open parts of the *Combretum* woodland. The gradation is so fine that it is not possible to mark all the boundaries on the scale at which the map is prepared.

TYPE 3 — *ACACIA GIRAFFAE* WOODLAND

In certain restricted areas *Acacia giraffae* becomes dominant and these patches, whilst in the basin in the Kalahari sand woodland, tend to be on the ecotone between that association and the *Combretum*. The species composition of two samples is as follows:—

Sample Line No.	*19*	*20*	*Total*	*Mean %*
Acacia galpinii Burtt Davy	4	—	4	2·0
A. giraffae Burch.	39	22	61	30·5
Combretum hereroense Schinz	—	23	23	11·5
C. zeyheri Sond.	—	10	10	5·0
Dichrostachys cinerea (L.) Wight & Arn.	4	11	15	7·5
Grewia sp.	5	17	22	11·0
Peltophorum africanum Sond.	3	4	7	3·5
Rhus sp.	43	11	54	27·0
Terminalia sericea Burch.	2	2	4	2·0
TOTAL	100	100	200	100·0

The species composition shows stronger affinities with the *Combretum* woodland than with that of the Kalahari sand proper. The trees, particularly the Acacias, are large and well grown. A curious feature is the presence of a considerable number of dead specimens of mature *Acacia giraffae*.

TYPE 3A — AREAS OF ENCROACHMENT OF SAPLINGS FROM THE *ACACIA GIRAFFAE* WOODLAND

In the vlei in front of Main Camp the only mature trees are a number of *Ziziphus mucronata* growing on termitaria but there is a considerable encroachment, mostly of thorny species, the composition of which is shown by the following sample lines:—

Sample Line No.	*1*	*2*	*3*	*Total*	*Mean %*
Acacia galpinii Burtt Davy	1	—	1	2	0·65
A. giraffae Burch.	54	28	85	167	54·42
Combretum hereroense Schinz	1	5	—	6	1·96
Dichrostachys cinerea (L.) Wight & Arn.	—	5	9	14	4·58
Diospyros lycioides Desf.	20	2	—	22	7·21
Gardenia sp.	—	1	—	1	0·33
Grewia sp.	—	9	2	11	3·60
Maytenus senegalensis (Lam.) Exell	—	6	—	6	1·96
Lonchocarpus capassa Rolfe	20	—	—	20	6·55
Rhus sp.	3	5	3	11	3·60
Ziziphus mucronata Willd.	1	24	1	26	8·52
Unidentified	3	16	—	19	6·23
TOTAL	103	101	101	305	99·61

Encroachment in this area is largely in the form of a spread from the bush edge out into the grassland. Dense thorny thickets are in process of formation.

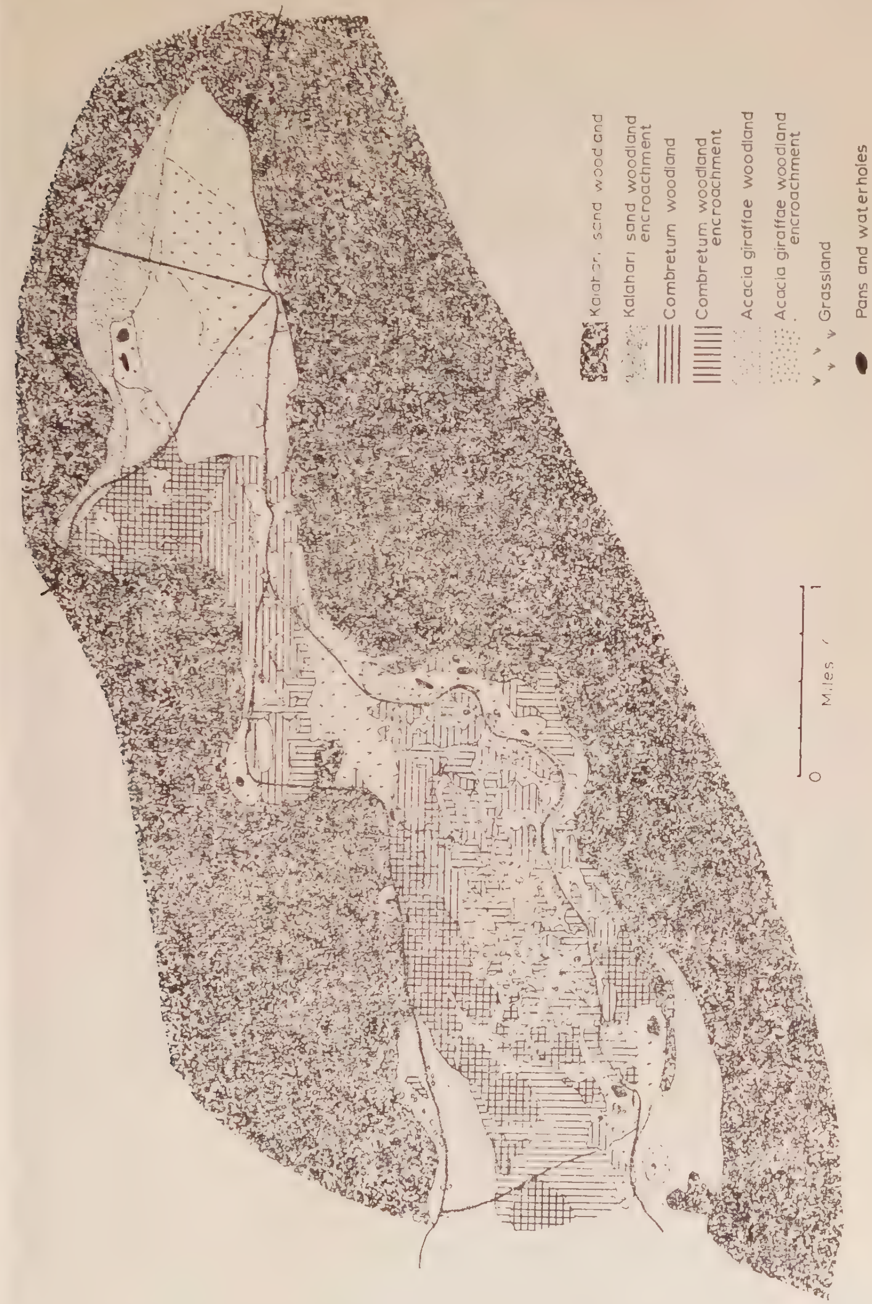
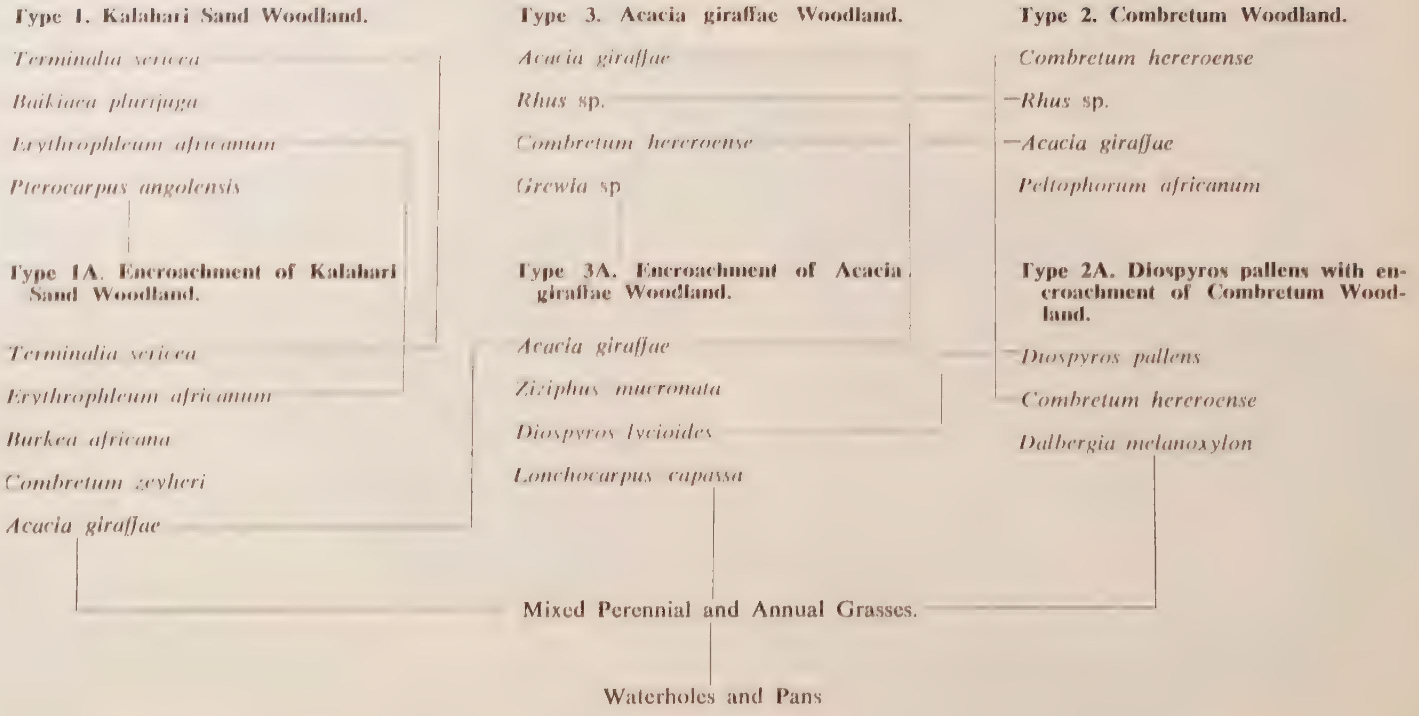

Kalahari sand woodland
Kalahari sand woodland encroachment
Combretum woodland
Combretum woodland encroachment
Acacia giraffae woodland
Acacia giraffae woodland encroachment
Grassland
Pans and waterholes
0
Miles
1

Figure 2.—Showing distribution of major vegetation types on ten-mile drive. Note the considerable area on left combining *Combretum* woodland and *Combretum* woodland encroachment. This area consisted of such a tight mosaic of small islands of woodland surrounded by woodland encroachment that it was impractical to separate the islands on a map.

FIGURE 3.

VEGETATION OF TEN-MILE DRIVE
WANKIE NATIONAL PARK

Diagram of Interrelations of the Main Associations



DISCUSSION

Figure 3 shows the manner in which the various associations are related to one another by the presence of certain species in two or more groups.

Above the waterholes and pans at the very bottom of the drainage is a zone which is trampled bare by large numbers of animals coming to drink during the dry season. Due to excessive grazing and hoof action perennial grasses are eliminated and the zone can support only a crop of annual grasses during the rains. This is followed by a zone of mixed perennial and annual grasses. Above this again woody vegetation appears as an encroachment of the saplings into the grassland. Which of the three types of woodland associations is represented in this regeneration is doubtless decided by soil factors. The zones of encroachment border on the grasslands with a very irregular margin but eventually give way abruptly to the main woodland types.

There is no doubt that what, in the fairly recent past, was perennial grassland has been disturbed in succession (Bayer, 1955) resulting in encroachment on the one hand by annual grasses and on the other by dense stands of woody saplings.

There are two causes which could account for this state of affairs and it is likely that both of these factors have contributed in some degree to the present state of the vegetation. A vigorous policy of early burning has been carried out for some years with the dual purpose of attracting game to the early grazing and of making the animals available for viewing by tourists (Davison, oral communication, November, 1959). The area has been burned every year early in the dry season for nearly 30 years. Owing to lack of flammable material in recent years it has been possible to burn only in alternate years. Thus without causing any damage to the woody elements the perennial grasses have been weakened and degraded. The perennial grasses are on the way out and are being replaced both by the annual species and by bush encroachment.

Further the artificial boosting of water supplies during the winter and spring months has resulted in a regular annual concentration of game animals during the dry season in excess of the populations which must have been present at the time when the various vegetational belts were being maintained in their previous ecologically stable conditions. Under natural conditions, with no artificial water and no early burning, drought seasons would have caused the game to migrate *en masse* to more favourable areas resulting in a natural rotation of grazing and resting of the vegetation. Flammable material would have been available in some years for an occasional fierce October fire caused by lightning which would hold bush encroachment in check and maintain the perennial grasses in a vigorous condition (West, 1955).

The continuous heavy grazing pressure in the dry season superimposed upon the damaging effects of constant early burning is causing the vegetation to alter at a high artificial rate. Where this change will eventually lead I am not qualified to say. However there is no doubt that grazing has already deteriorated and that the woody regeneration is already sufficiently dense to obstruct visibility for game viewing.

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